REPORT RESUMES

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THE EFFECTIVENESS OF ADJUNCT AUTO-INSTRUCTION.
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THE QUESTION OF PRIMARY CONCERN IN FOUR STUDIES WAS IMMEDIATE FEEDBACK IN ADJUNCT AUTOINSTRUCTIONAL EXERCISES (LEARNING EXERCISES DEFINED AS THOSE DESIGNED TO TAKE ADVANTAGE OF THE STRUCTURE INHERENT IN SUBJECT MATTER). IN A CONTROLLED SITUATION, DIFFERENT FEEDBACK DELAYS (IMMEDIATE, 1-HOUR DELAY, 2-DAY DELAY, AND 1-WEEK DELAY) WERE TESTED. OTHER OBJECTIVES WERE (1) TO PREPARE AND TEST ADJUNCT AUTOINSTRUCTIONAL EXERCISES IN FOUR COURSES REPRESENTING DIFFERENT SUBJECT-MATTER (COMPUTER TECHNIQUES, HIGH SCHOOL ALGEBRA, JUNIOR HIGH SCHOOL GENERAL SCIENCE, AND EDUCATIONAL PSYCHOLOGY) AND AT DIFFERENT GRADE LEVELS, AND (2) TO DETERMINE WHETHER CLASSROOM TEACHERS WITH SUFFICIENT ENCOURAGEMENT CAN DEVELOP ADJUNCT AUTOINSTRUCTIONAL EXERCISES. MATERIALS WERE DEVELOPED FOR USE IN COURSES IN THE FOUR SUBJECT MATTERS. THE WORK WITH THESE COURSES CONSTITUTED FOUR SEPARATE EXPERIMENTAL STUDIES, REPORTED SEPARATELY BECAUSE OF VARIATIONS IN PROCEDURES. SIGNIFICANT DIFFERENCES ON FINAL EXAMINATION SCORES OF PARTICIPATING STUDENTS WERE NOT DEMONSTRATED BETWEEN EXPERIMENTAL GROUPS WHICH RECEIVED IMMEDIATE KNOWLEDGE OF RESULTS AND CONTROL GROUPS WHICH DID NOT RECEIVE SUCH FEEDBACK IN THREE SUBJECTS. SIGNIFICANT DIFFERENCES WERE FOUND ON MIDTERM EXAMINATIONS FOR COMPUTER TECHNIQUES. IN THE COURSE IN EDUCATIONAL PSYCHOLOGY THERE WERE FOUR TREATMENT CONDITIONS. IN NO INSTANCE WAS IMMEDIATE FEEDBACK SUPERIOR TO DELAYED FEEDBACK. TOO FEW TEACHERS WERE INVOLVED IN THE EXPERIMENTS TO GET A DEFINITE ANSWER RELATIVE TO TEACHERS PREPARING ADJUNCT AUTOINSTRUCTIONAL EXERCISES. (REFER TO ACCESSION NUMBER ED 003 336 FOR INFORMATION ON AN EARLIER STUDY OF ADJUNCT AUTOINSTRUCTION.) (JC)

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Cooperative Research Project No. 2761

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Chapter I

Introduction

This project is a continuation of Cooperative Research Project No. 2306 "The Effectiveness of Adjunct Auto-Instruction" of which Sidney L. Pressey was the Principal Investigator.

Although Dr. Pressey is the inventor of the teaching machine, he does not believe machines to be necessary to provide the knowledge of results required to bring about effective learning. Neither does he believe that it is necessary to destroy the overall structure of the material to be learned through making so-called programs consisting of units strung out in very small steps, each step being confirmed before the next step is taken. The small unit method of presentation makes it particularly difficult for a student to obtain an overview of what is learned and to engage in selective use and review of the material.

Dr. Pressey uses the term "adjunct auto-instruction" to refer to the materials used in conjunction with and supplementary to the structured material to be learned in a given course of study. The adjunct auto-instructional material developed for this study consisted of multiple-choice questions which were used only after a first reading of the subject matter. The possible choices consisted of a correct answer and usually two or three incorrect answers which involve common misunderstandings. Rarely were the adjunct auto-instructional questions presented with other than three choices. The questions were planned to inform the student when he is right and to identify and correct any misconceptions. For immediate knowledge of results Trainer-Tester Response Cards were used (See Appendix E). The Trainer-Tester Response Cards were developed by Van Valkenburgh, Nooger, and Neville, Inc. especially for these projects. The cards are 3 x 5 inches in size and contain spaces for keying the answers to 30 multiple-choice questions using the three-choice format. Immediate knowledge of results was provided by the appearance of the letter "R" when the student erased a light ink overlay. Incorrect responses were designated by nothing under the overlay.

The previous study raised several questions which demanded further investigation. Although all questions could not be studied, certain ones remained urgent. One was the question of whether feedback in the form of knowledge of results need be immediate if the material is structured and meaningful. Another question was why so little transfer was obtained from specific learnings to other responses which were assumed to be similar or related through the application of a principle. Often the similarity or principle was not perceived. Also, might there be a difference in transfer due to the nature of the subject matter content? This led the investigators to question whether one would find differences in other subject matter areas and for other grade levels.

Since previous research by Pressey and associates in the earlier project had indicated also that adjunct auto-instructional material is effective in bringing about higher scores on chapter tests in the educational psychology course, Human Growth and Learning, it was proposed that the work be extended in these ways.

1. To determine whether the adjunct auto-instructional technique can be successfully utilized at other educational levels and with other subject matter.
2. To determine whether classroom teachers with encouragement can adequately develop auto-instructional material.
3. To determine whether immediate feedback is an essential element in meaningful learning with human subjects.

During the early portion of the project materials were developed in computer programing, algebra, and certain general science topics. The materials used in the course Human Growth and Learning were primarily revisions of previously used materials and were used as learning exercises after an original presentation of the material by means of reading, lectures, and discussions. The supplementary nature of these learning exercises must be emphasized. They are not used for initial presentation; they are used only after an initial structured presentation has been made.

Adjunct auto-instruction is more than a protest against current programing practices. It represents a point of view about learning that is markedly different from the operant conditioning paradigm. The human organism is capable of understanding the structure of the material to be learned and it is capable of understanding the goals of the textbook writer or the teacher. This is in marked contrast to the situation presented to laboratory animals. The experimenter in the case of the laboratory experiment with animals does not require that the learning organism get an overview of the experiment or of the task to be learned. This overview or preview the investigators believe to be vital to the learning process.

In the operant conditioning situation the experimenter contrives a situation that forces the organism to emit the expected response and the organism is rewarded when this response is made. This contrived situation works in man as it does in a pigeon, but to assume that all human learning fits this model is to shut one's eyes to the main difference between man and the other animals. Bad observation is just as bad science as bad theory construction, and it is probably more fundamental.

This research is premised on the assumption that man's possession of language makes it possible for him to structure a world much more elaborate than that of the laboratory animal. Also, to teach man by methods premised upon the operant conditioning model is to leave the uniquely human learning untouched.

The adjunct auto-instructional methodology is premised on the notion that man can read, that he can respond to questions by selecting an answer from multiple choices stated in language, and that he can learn from mistakes if he is aware that his response is a mistake. A mistake can lead to learning if the subject is aware that his mistake is a response neither consistent with his other responses nor consistent with the structure of the body of knowledge he is learning.

Another assumption one must consider is that man seldom learns anything that is not related to something he has previously learned. This binding of man's experiences through time by means of language, especially written language, is one of the important differences between man and other animals. This is an assumption that must be made if one is to deal with meaningful human learning.

To carry out the various aspects of the project it was divided into four parts, each to be carried out somewhat independently of the others. The four subject matters are assumed to represent a range from the simple and precise at one end of the scale to the complex and theoretical at the other.

It will be observed too, that the most and the least precise content were in those courses at the University level while the intermediate positions on the scale are secondary school subjects.

Chapter II

Computer Techniques

Purpose

It was proposed to investigate the effectiveness of adjunct auto-instruction in learning situations varying as to clearness of objectives and preciseness of structure. This chapter is a report of a study concerned with a college level course which possesses these characteristics to a high degree. It is a course in Computer Techniques (Engineering 70) at the University of Arizona, a one semester hour credit course which meets weekly for a three hour period. The course is concerned primarily with what a computer can do and how to work out a sequence of instructions to which the computer will respond so that a desired sequence of operations is performed.

Materials

Materials for the study consisted of a textbook by the instructor of the course, James W. Perry, Computer Programming, An Introductory Text, a supplementary textbook, D. P. McCracken, A Guide to Fortran Programming, a pad of Fortran forms, control cards, and learning exercises with Trainer-Tester Response Cards.

The IBM 7072 Computer in the Numerical Analysis Laboratory was used to check the programs worked out by the students.

Subjects

The subjects were students in a multiple section course in the College of Engineering, most of them freshmen or sophomores. The students in this study were from two sections, a morning section and an afternoon section, taught by the same instructor. For each student age, grade point average, hours in mathematics, and scores on the Otis Quick Scoring Mental Ability Test, Gamma, were obtained.

Procedure

Each semester one section was used as a control group and one as an experimental group, the morning section being the control group the first semester and the experimental group the second semester.

The course was taught by one instructor, who gave all the lectures, aided by two assistants who supervised the students' card punching, correction of programing errors, and evaluation of the computer's output. Each group was given the same reading and program assignments. The same service in running programs on the computer was provided each student. Care was taken to keep the lectures for the groups approximately the same.

During the last hour of each class period the experimental group was given 30, three-choice, multiple-choice adjunct auto-instructional exercises, prepared by the instructor, using Trainer-Tester Response Cards by which the student would learn immediately the correct answer.

Upon completion of the exercises, there was opportunity for questions to clarify difficulties. Subsequent instructional exercises sometimes repeated items upon which there had been earlier incorrect responses. As it was emphasized that these exercises were not tests but aids to learning, materials put on blackboards during the lecture were not erased before the exercises were given. The control group used the time required for adjunct auto-instruction for questions and discussion.

Analysis and Results

The problem to be put to test was whether a group using adjunct auto-instruction was more effective in learning course materials in computer programing than a group taking the same course without the use of such instruction.

The hypothesis of no difference between the experimental and control groups was tested using an analysis of covariance technique (5) with scores of individuals. The scores for individuals which provided the basis for statistical tests of group differences were obtained from:

1. Examination I, Part 1 (Transfer items, designed to measure ability to apply principles to new problems)
2. Examination I, Part 2 (Paraphrased items, paraphrases of items used previously in auto-instructional exercises)
3. Examination I, Part 3 (Identical items, taken verbatim from previous auto-instructional exercises)

4. Examination II, Part 1 (Transfer items)
5. Examination II, Part 2 (Paraphrased items)
6. Examination II, Part 3 (Identical items)
7. Final Examination (Multiple Choice items)
8. Number of programs handed in late (All programs were required to be "de-bugged" and operational before being turned in.)
9. Final program grade (Laboratory)

Variables considered in covariance for the analysis of first semester scores were:

1. Age in years
2. Grade point average
3. Otis Gamma

Variables considered in covariance for the analysis of second semester scores were:

1. Age in years
2. Grade point average
3. Otis Gamma
4. Hours in mathematics

Means for variables considered in the analysis for the experimental group, the control group, and the two groups merged, for the first and second semesters, are shown in Table I. Standard deviations are shown for the two groups merged for each semester. Intercorrelation

TABLE I

MEANS FOR THE EXPERIMENTAL GROUP, THE CONTROL GROUP, AND THE GROUPS MERGED, WITH STANDARD DEVIATIONS FOR THE GROUPS MERGED, COMPUTER TECHNIQUES

	Group Means			Std. Dev.
	Experimental	Control	Groups Merged	Groups Merged
First Semester: Experimental (N = 19) Control (N = 20)				
Age	20.947	23.000	22.000	5.341
Grade Point Average	2.255	2.661	2.463	0.633
Otis Gamma	67.105	64.650	65.846	9.033
Late Programs	2.579	4.600	3.615	2.412
Final Program Grade	1.910	2.625	2.277	1.083
Exam I, Part 1	95.368	89.500	92.359	7.665
Exam I, Part 2	27.316	25.400	26.333	2.537
Exam I, Part 3	53.632	49.850	51.692	4.425
Exam II, Part 1	63.474	57.150	60.231	6.595
Exam II, Part 2	46.895	43.750	45.282	4.914
Exam II, Part 3	46.263	42.600	44.385	4.716
Final Examination	115.474	111.050	113.205	8.498
Second Semester: Experimental (N = 20) Control (N = 24)				
Age	21.600	20.542	21.023	3.426
Grade Point Average	2.798	2.559	2.668	0.550
Otis Gamma	62.600	64.500	63.636	9.243
Number Hours, Math	13.300	10.000	11.500	5.555
Final Program Grade	76.250	73.417	74.705	18.723
Exam I, Part 1	90.350	87.792	88.955	6.003
Exam I, Part 2	58.400	57.708	58.023	3.769
Exam I, Part 3	27.150	25.667	26.341	2.632
Exam II, Part 1	78.600	73.875	76.023	7.039
Exam II, Part 2	38.950	37.333	38.068	3.336
Exam II, Part 3	64.900	62.708	63.705	4.815
Final Examination	96.900	93.875	95.250	6.224

matrices including all these variables are given for the two semesters in Table II.

The computed regression coefficients, constants, coefficient of multiple correlation, and appropriate test statistics are presented for each semester. Summaries of the results for the first and second semesters are given in Tables III and IV respectively. The value of the test statistic, F, associated with the group variable indicates the significance of the difference between groups.

The group differences, for each semester, in the final examination and the final program grade were not significant. The group difference for programs in late was not significant when used the first semester.

The group difference on transfer items in Examination II, Part 1, was significant (0.05 level) for both the first and second semesters.

The group difference on paraphrased items in Examination I, Part 2, was significant (0.05 level) the first semester.

The group difference on identical items in Examination I, Part 3, was significant (0.05 level) for both the first and second semesters.

All significant differences on transfer items, paraphrased items, and identical items favor the experimental group.

Conclusions

The findings of this study indicate for each semester significant differences between the experimental and control groups for transfer

TABLE II

INTERCORRELATION MATRICES, COMPUTER TECHNIQUES

First Semester (N = 39)

	2	3	4	5	6	7	8	9	10	11	12
1. Age	.085	-.298	.229	.211	.072	-.089	.095	-.270	-.148	-.244	-.165
2. Grade Point Average		-.277	.477	.495	-.553	-.237	-.529	-.430	-.416	-.392	-.482
3. Otis Gamma			-.143	-.287	.329	.424	.296	.312	.219	.508	.460
4. Late Programs				.373	-.325	-.056	-.509	-.399	-.366	-.317	-.208
5. Final Program Grade					-.444	-.362	-.290	-.581	-.456	-.426	-.632
6. Examination I, Part 1						.327	.660	.681	.612	.570	.656
7. Examination I, Part 2							.368	.505	.307	.466	.406
8. Examination I, Part 3								.599	.659	.627	.389
9. Examination II, Part 1									.720	.687	.552
10. Examination II, Part 2										.645	.462
11. Examination II, Part 3											.638
12. Final Examination											

Second Semester (N = 44)

	2	3	4	5	6	7	8	9	10	11	12
1. Age	.133	-.080	.289	.152	.197	-.205	.298	.181	.030	.071	.112
2. Grade Point Average		-.248	-.027	-.287	-.327	-.039	-.218	-.029	-.203	-.216	-.296
3. Otis Gamma			-.094	.300	.083	.396	-.001	.246	.277	-.139	.247
4. Hours in Math				.130	.059	-.013	-.044	.014	.161	.121	.212
5. Final Program Grade					.704	.342	.216	.468	.275	.299	.524
6. Examination I, Part 1						.306	.415	.473	.380	.391	.547
7. Examination I, Part 2							.123	.437	.399	.268	.481
8. Examination I, Part 3								.431	.394	.302	.540
9. Examination II, Part 1									.495	.450	.578
10. Examination II, Part 2										.444	.651
11. Examination II, Part 3											.566
12. Final Examination											

Note: $r_{05}(\text{d.f.} = 35) = 0.325$, $r_{01}(\text{d.f.} = 35) = 0.418$

$r_{05}(\text{d.f.} = 40) = 0.304$, $r_{01}(\text{d.f.} = 40) = 0.393$

TABLE III

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM COMPUTER TECHNIQUES, FIRST SEMESTER

	Examination I - Part 1			Examination I - Part 2			Examination I - Part 3		
	Regression Coefficients and Constants With R	Test Statistic F	d. f.	Regression Coefficients and Constants With R	Test Statistic F	d. f.	Regression Coefficients and Constants With R	Test Statistic F	d. f.
X_1 Age	+ 0.33312 X_1	2.853	1	+ 0.04633 X_1	0.406	1	+ 0.21285 X_1	3.509	1
X_2 Grade Point Average	- 5.08101 X_2	8.833**	1	- 0.09964 X_2	0.025	1	- 2.67744 X_2	7.389*	1
X_3 Otis Gamma	+ 0.20875 X_3	3.070	1	+ 0.11214 X_3	6.522*	1	+ 0.10829 X_3	2.488	1
Group - if experimental - if control	+ 1.98897 - 1.98897	3.581	1	+ 0.84756 - 0.84756	4.787*	1	+ 1.43309 - 1.43309	5.600*	1
Constant	+83.85074			+18.19736			+46.51076		
Multiple Correlation R	0.657			0.544			0.659		
Error Variance	37.318			5.069			12.388		
Degrees of Freedom:Error	34			34			34		
	Examination II - Part 1			Examination II - Part 2			Examination II - Part 3		
X_1 Age	- 0.16476 X_1	0.847	1	- 0.05261 X_1	0.127	1	- 0.05031 X_1	0.162	1
X_2 Grade Point Average	- 2.72644 X_2	3.087	1	- 2.51011 X_2	3.846	1	- 1.41142 X_2	1.696	1
X_3 Otis Gamma	+ 0.11069 X_3	1.048	1	- 0.04659 X_3	0.273	1	+ 0.20987 X_3	7.721**	1
Group - if experimental - if control	+ 2.30370 - 2.30370	5.831*	1	+ 0.95191 - 0.95191	1.463	1	+ 1.23594 - 1.23594	3.440	1
Constant	+63.34132			+49.57859			+35.18014		
Multiple Correlation R	0.606			0.475			0.630		
Error Variance	30.743			20.917			14.997		
Degrees of Freedom:Error	34			34			34		
	Final Examination			Late Programs			Final Program Grades		
X_1 Age	- 0.01989 X_1	0.007	1	+ 0.07086 X_1	1.105	1	+ 0.02188 X_1	0.508	1
X_2 Grade Point Average	- 4.74631 X_2	5.548*	1	+ 1.47691 X_2	6.389*	1	+ 0.68092 X_2	6.549*	1
X_3 Otis Gamma	+ 0.32482 X_3	5.350*	1	+ 0.01306 X_3	0.103	1	- 0.01464 X_3	0.623	1
Group - if experimental - if control	+ 0.82972 - 0.82972	0.449	1	- 0.65419 + 0.65419	3.316	1	- 0.17866 + 0.17866	1.193	1
Constant	+103.96642			- 2.45765			+ 1.43529		
Multiple Correlation R	0.598			0.575			0.557		
Error Variance	51.845			4.359			0.904		
Degrees of Freedom:Error	34			34			34		

*Significant, five per cent level
**Significant, one per cent level

TABLE IV

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM COMPUTER TECHNIQUES, SECOND SEMESTER

	Examination I, Part 1			Examination I, Part 2			Examination I, Part 3		
	Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.
X_1 Age	+ 0.41928 X_1	2.582	1	- 0.23783 X_1	2.032	1	+ 0.27979 X_1	6.555*	1
X_2 Grade Point Average	- 4.62475 X_2	7.912**	1	+ 0.43084 X_2	0.168	1	- 1.77676 X_2	6.658*	1
X_3 Otis Gamma	+ 0.01174 X_3	0.015	1	+ 0.16854 X_3	7.701**	1	- 0.01436 X_3	0.130	1
X_4 Hours, Mathematics	- 0.12004 X_4	0.516	1	+ 0.03275 X_4	0.094	1	- 0.13249 X_4	3.582	1
Group - if experimental	+ 1.81852	4.021	1	+ 0.52634	0.824	1	+ 1.01065	7.081*	1
- if control	- 1.81852			- 0.52634			- 1.01065		
Constant	+93.27711			+50.81898			+27.72875		
Multiple Correlation R	0.496			0.467			0.558		
Error Variance	30.758			12.573			5.395		
Degrees of Freedom:Error	38			38			38		
	Examination II, Part 1			Examination II, Part 2			Examination II, Part 3		
X_1 Age	+ 0.39294 X_1	1.625	1	+ 0.00657 X_1	0.002	1	+ 0.08205 X_1	0.139	1
X_2 Grade Point Average	- 0.99442 X_2	0.262	1	- 1.19963 X_2	1.622	1	- 2.88976 X_2	4.330*	1
X_3 Otis Gamma	+ 0.20573 X_3	3.361	1	+ 0.09628 X_3	3.131	1	- 0.09791 X_3	1.489	1
X_4 Hours, Mathematics	- 0.17213 X_4	0.760	1	+ 0.05613 X_4	0.344	1	- 0.00379 X_4	0.001	1
Group - if experimental	+ 2.75271	6.604*	1	+ 0.94690	3.323	1	+ 1.31057	2.928	1
- if control	- 2.75271			- 0.94690			- 1.31057		
Constant	+59.55279			+34.44417			+76.08228		
Multiple Correlation R	0.484			0.446			0.405		
Erro. Variance	42.919			9.250			21.943		
Degrees of Freedom:Error	38			38			38		
	Final Examination			Final Program Grade					
X_1 Age	+ 0.17234 X_1	0.409	1	+ 0.94527 X_1	1.272	1			
X_2 Grade Point Average	- 3.55860 X_2	4.387*	1	- 9.10436 X_2	2.972	1			
X_3 Otis Gamma	+ 0.14603 X_3	2.213	1	+ 0.53913 X_3	3.122	1			
X_4 Hours, Mathematics	+ 0.12283 X_4	0.506	1	+ 0.21372 X_4	0.158	1			
Group - if experimental	+ 1.78211	3.616	1	+ 2.16267	0.551	1			
- if control	- 1.78211			- 2.16267					
Constant	+90.57721			42.55273					
Multiple Correlation R	0.501			0.447					
Error Variance	32.847			317.311					
Degrees of Freedom:Error	38			38					

*Significant, five per cent level
**Significant, one per cent level

items, paraphrased items, and identical items on mid-term examinations. No significant group differences occur for the final examination, final program grade, or number of programs in late. All significant differences favor the experimental group.

Chapter III

High School Algebra

Purpose

The purpose of this phase of the project was to study the effect of adjunct auto-instruction in a class at the high school level in which there was a high degree of clarity of objectives and preciseness of structure. A course in first year algebra at the Flowing Wells High School, Tucson, Arizona, was selected.

Materials

The investigation used units three, five, and nine, of Algebra: Its Big Ideas and Basic Skills, by Daymond J. Aiken. Other materials included First Year Algebra Tests by Ray Webb, Test I, Forms A and B, Test II, Forms A and B; the Kuhlmann-Anderson Intelligence Test, Form H; the Otis Quick-Scoring Mental Ability Tests, New Edition, Gamma Em; Trainer-Tester Response Cards; and specially prepared forms.

Adjunct auto-instructional exercises were specially constructed for each unit studied. The first unit of the course was used primarily for practice in preparing adjunct auto-instructional items. An exercise consisted of twenty, three-choice items. Each item involved a concept which had been observed to be misunderstood by many students. The incorrect choices represented misconceptions frequently encountered.

The instructional exercises in the completion format were constructed by rephrasing the adjunct auto-instructional exercises and deleting the choices.

A pre-test and a post-test were prepared for each unit. These tests consisted of fifty items of which twenty were in multiple-choice form with five choices and thirty were of the constructed response type. The post-test format consisted of the fifteen to eighteen items most frequently missed on the pre-test, fifteen to eighteen paraphrased items from the pre-test, and some new items.

Subjects

The subjects were one hundred fifteen students in five sections of Algebra I. The students were assigned to sections in terms of previous school achievement as judged by former teachers, aptitude tests, and intelligence tests. It was found, however, that differences in ability as shown by pre-tests were relatively small. The sections were taught by three instructors. Instructor A taught Experimental Group I and Experimental Group II. Instructor B taught Control Group I. Instructor C taught two sections which were combined into what was termed Control Group II.

Procedures

Students were given the Kuhlmann-Anderson Test when they entered the ninth grade which meant that some took it three years earlier than others. The Otis Mental Ability Test was administered to all in

April 1965. The appropriate forms of the Webb Algebra Tests were also given to all students as pre-tests and post-tests each semester.

The classes met for four seventy-minute periods per week, twenty minutes of the period being considered study time.

Experimental Group I received for each unit, a pre-test, a series of adjunct auto-instructional exercises using Trainer-Tester Response Cards to furnish immediate feedback, and a post-test. The time required to complete the exercises was from eight to twelve minutes. The plan was to assign and discuss a topic on a certain day, discuss it further at the next class meeting, and give the exercises at the beginning of the class period following the second discussion. If student questions following the exercises indicated that misunderstandings persisted there was additional discussion.

Experimental Group II received for each unit, a pre-test, instructional exercises in the completion format, and a post-test. The instructional exercises in the completion format were so arranged that the student read the first exercise and wrote what he considered to be the correct response while covering all other material below the exercise, read that exercise and wrote his response, moved the card down to expose the correct answer to the first exercise for comparison, moved the card down to expose the following exercise and continued through the set of exercises in this manner. The student was on his honor not to look at the correct answer before making his response.

Control Group I received for each unit a pre-test and a post-test.

Control Group II received none of the unit tests or adjunct auto-instructional exercises provided for the experimental groups.

During the first semester the two experimental groups fell behind the other groups in relation to the textbook. Then in December the instructor of the experimental groups became ill and a substitute teacher, an English teacher, conducted the classes. This substitute continued to use the instructional exercises but the classes at the end of the semester were far behind the other groups. The regular teacher returned in February and by the end of the year his classes were nearly up with the others, but the last part of the work was done under considerable pressure.

Data Analysis

Two kinds of measurements, scores for each individual and percentages for each item, were used for testing the hypothesis of no difference for the four groups: Control I, Control II, Experimental I, Experimental II.

The scores for individuals which provided a basis for statistical tests of differences were obtained from:

1. Webb, First Year Algebra, Test I, Semester I, Form B
2. Difference Score: Webb, Test I, Form A minus Webb, Test I, Form B

3. Webb, First Year Algebra, Test II, Semester II, Form B
4. Difference Score: Webb, Test II, Form A minus Webb, Test II, Form B
5. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Three, Verbatim Items
6. Gain Score (R-R): Number right responses on pre-test remaining right on post-test, Unit Three, Verbatim Items
7. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Three, Paraphrased Items
8. Gain Score (R-R): Number of right responses on pre-test remaining right on post-test, Unit Three, Paraphrased Items
9. Total Score New Items: Number of new items right on post-test, Unit Three
10. Total Score: Number right on post-test, Unit Three
11. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Five, Verbatim Items
12. Gain Score (R-R): Number right responses on pre-test remaining right on post-test, Unit Five, Verbatim Items

13. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Five, Paraphrased Items

14. Gain Score (R-R): Number of right responses on pre-test remaining right on post-test, Unit Five, Paraphrased Items

15. Total Score New Items: Number of new items right on post-test, Unit Five

16. Total Score: Number right on post-test, Unit Five

17. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Nine, Verbatim Items

18. Gain Score (R-R): Number right responses on pre-test remaining right on post-test, Unit Nine, Verbatim Items

19. Gain Score (W-R): Number of wrong responses on pre-test changed to right responses on post-test, Unit Nine, Paraphrased Items

20. Gain Score (R-R): Number of right responses on pre-test remaining right on post-test, Unit Nine, Paraphrased Items

21. Total Score New Items: Number of new items right on post-test, Unit Nine

22. Total Score: Number right on post-test, Unit Nine

The scores for individuals were subjected to an analysis of covariance using the regression method in order to test the hypothesis of no difference for the four groups. The variables considered in covariance for the various analyses were:

1. Kuhlmann-Anderson, Form H
2. Pre-Test, Webb, Test I, Form B, or Test II, Form B
3. Pre-Test, Unit Three, Five, or Nine
4. Otis, New Edition Gamma Em
5. Sex
6. Grade level: ninth, tenth, eleventh, twelfth

The percentages computed for verbatim and paraphrased items for units three, five, and nine are:

1. Percentage of wrong responses on the pre-test which changed to right on the post-test
2. Percentage of right responses on the pre-test which remained right on the post-test

The sign test (3), a non-parametric test, was used to test the hypothesis of no difference between Control I and Experimental I groups and between Control I and Experimental II groups, where the percentages for items were considered.

Analysis of Scores for Individuals

The hypothesis of no difference for the four groups (Control I, Control II, Experimental I, and Experimental II) was tested using an analysis of covariance (5) technique with scores for individuals. Post-test scores from units three, five, and nine and scores on Webb's First

Year Algebra Tests I and II, Form A were considered for the statistical analysis.

Means for variables in the analysis, computed for each group, and the groups merged, are shown in Table V. Standard deviations for the groups merged are also shown. An intercorrelation matrix for the variables considered in the analyses are shown in Table VI.

The results of the analyses of covariance by regression methods of scores from Webb, First Year Algebra Test I, Form A, and the Difference Score for Webb Test I, are presented in Table VII.

The variables considered in covariance for the analyses are:

1. Kuhlmann-Anderson, Form H
2. Pre-Test, Webb, Test I, Form B
3. Otis, New Edition Gamma Em
4. Sex
5. Grade level: ninth, tenth, eleventh, twelfth

The hypothesis of no difference for the four groups can be rejected (0.01 level). The difference on this mid-year test favors the control group.

The results of the analyses of covariance of scores from Webb First Year Algebra Test II, Form A and the Difference Score for Webb Test II are shown in Table VIII. The variables considered in covariance for the analyses are:

TABLE V

MEANS FOR THE EXPERIMENTAL GROUPS, THE CONTROL GROUPS AND THE GROUPS MERGED, WITH STANDARD DEVIATIONS FOR THE GROUPS MERGED, HIGH SCHOOL ALGEBRA

	Means					Std. Dev.
	Exp. I (N = 18)	Exp. II (N = 25)	Cont. I (N = 27)	Cont. II (N = 45)	Groups Merged	Groups Merged
Kuhlmann-Anderson, Form H	107.778	113.400	110.259	113.756	111.922	12.277
Otis, New Edition Gamma Em	110.944	110.00C	111.370	111.133	110.913	8.934
Pre-test, Webb Test I, Form B	15.056	14.400	13.037	15.222	14.504	4.029
Pre-test, Webb Test II, Form B	13.778	15.560	18.593	17.911	16.913	4.725
Post-test, Webb Test II, Form A	19.167	21.600	20.667	22.711	21.435	7.449
Difference Score, Webb Test II	5.389	6.040	2.074	4.800	4.522	5.742
Unit 3, Pre-test	27.889	27.240	29.259		28.186	8.202
Unit 3, Post-test	34.500	32.200	35.296		33.986	7.382
Unit 3, Verbatim, W-R	4.167	4.840	4.074		4.371	1.986
Unit 3, Verbatim, R-R	7.500	6.520	8.000		7.343	3.442
Unit 3, Paraphrased, W-R	4.500	4.520	4.444		4.486	1.946
Unit 3, Paraphrased, R-R	7.889	6.680	8.296		7.614	3.431
Unit 3, Post-test, New Items	10.444	9.640	10.481		10.171	2.383
Unit 5, Pre-test	14.500	16.200	17.148		16.129	5.835
Unit 5, Post-test	23.167	26.920	25.852		25.543	8.397
Unit 5, Verbatim, W-R	4.333	5.160	6.333		5.400	2.451
Unit 5, Verbatim, R-R	1.833	2.160	2.037		2.029	1.760
Unit 5, Paraphrased, W-R	5.833	5.360	4.037		4.971	2.146
Unit 5, Paraphrased, R-R	2.500	3.840	3.370		3.314	2.337
Unit 5, Post-test, New Items	8.667	10.400	10.074		9.829	3.562
Unit 9, Pre-test	11.222	12.480	13.074		12.386	4.861
Unit 9, Post-test	20.222	26, 320	23.556		23.686	8.933
Unit 9, Verbatim, W-R	3.778	5.720	4.000		4.557	3.151
Unit 9, Verbatim, R-R	0.556	1.240	0.593		0.814	0.889
Unit 9, Paraphrased, W-R	4.444	6.120	6.037		5.657	3.092
Unit 9, Paraphrased, R-R	1.556	2.280	2.593		2.214	2.132
Unit 9, Post-test, New Items	9.889	10.960	10.333		10.443	2.821

TABLE VI

INTERCORRELATION MATRIX, HIGH SCHOOL ALGEBRA (N = 70)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. Kuhlmann-Anderson, Form H	.674	.152	.281	.087	.119	.199	.138	.165	.271	.316	.171	.257	-.019	.065	.281	.372	.324	.100	.139	.082	.400	.118	.311	.392
2. Otis, New Edition Gamma Em		.192	.260	.274	-.112	.355	-.047	.321	.217	.362	.209	.233	.070	-.014	.288	.363	.313	.136	.300	-.038	.311	.118	.316	.337
3. Pre-Test, Webb, Test I, Form B				.519	-.238	.537	-.212	.637	.688	.651	.532	.093	.644	.228	.404	.561	.551							
4. Pre-Test, Webb, Test II, Form B																		.469	.07	.131	.413	.445	.319	.503
5. Unit 3 Pre-Test					-.563	.871	-.796	.848	.637	.751														
6. Unit 3 Verbatim, W-R						-.578	.534	-.666	-.176	-.123														
7. Unit 3 Verbatim, R-R							-.330	.790	.699	.817														
8. Unit 3 Paraphrased, W-R								-.680	-.204	-.061														
9. Unit 3 Paraphrased, R-R									.644	.793														
10. Unit 3 New Items Correct										.879														
11. Unit 3 Post-Test																								
12. Unit 5 Pre-Test												.213	.721	.063	.032	.497	.740							
13. Unit 5 Verbatim, W-R													.004	.041	.212	.439	.560							
14. Unit 5 Verbatim, R-R														.169	.186	.344	.648							
15. Unit 5 Paraphrased, W-R															.882	.231	.401							
16. Unit 5 Paraphrased, R-R																.668	.739							
17. Unit 5 New Items Correct																	.911							
18. Unit 5 Post-Test																								
19. Unit 9 Pre-Test																			.457	.419	.298	.748	.460	.630
20. Unit 9 Verbatim, W-R																				.136	.606	.443	.578	.884
21. Unit 9 Verbatim, R-R																					.129	.350	.103	.308
22. Unit 9 Paraphrased, W-R																						.187	.571	.798
23. Unit 9 Paraphrased, R-R																							.268	.579
24. Unit 9 New Items Correct																								.792
25. Unit 9 Post-Test																								

Note: $r_{.05}$(d.f. = 70) = 0.232, $r_{.01}$(d.f. = 70) = 0.302

TABLE VII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM WEBB

FIRST YEAR ALGEBRA TEST I, FORM A (N = 115)

		Y Post-Test, Webb Test I, Form A			Y Webb, Test I, Difference		
		Regression Coefficients and Constant, With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.
X_1	Kuhlmann-Anderson, Form H	+ 0.02656 X	0.206	1	+ 0.02656 X_1	0.206	1
X_2	Pre-Test, Webb, Test I,Form B	+ 0.72883 X	36.338**	1	- 0.27117 X_2	5.030*	1
X_3	Otis, New Edition, Gamma Em	+ 0.13010 X	3.989*	1	+ 0.13010 X_3	3.989*	1
	Group - if experimental I	- 3.83039	10.423**	3	- 3.83039	10.423**	3
	- if experimental II	- 1.16177			- 1.16177		
	- if control I	+ 3.89365			+ 3.89365		
	- if control II	+ 1.09851			+ 1.09851		
	Grade level - if ninth	- 0.36466	0.687	3	- 0.36466	0.687	3
	- if tenth	- 1.36361			- 1.36361		
	- if eleventh	+ 1.09071			+ 1.09071		
	- if twelfth	+ 0.63756			+ 0.63756		
	Sex - if male	- 0.55308	1.493	1	- 0.55308	1.493	1
	- if female	+ 0.55308			+ 0.55308		
	Constant	- 4.07508			- 4.07508		
	Multiple Correlation R	0.702			0.609		
	Error Variance	21.391			21.391		
	Degrees of Freedom:Error	104			104		

*Significant, five per cent level
**Significant, one per cent level

TABLE VIII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM WEBB FIRST YEAR ALGEBRA TEST II, FORM A (N = 115)

		Y Post-Test, Webb Test II, Form A			Y Webb Test II, Difference		
		Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.
X_1	Kuhlmann-Anderson, Form H	+ 0.06628 X_1	0.853	1	+ 0.06628 X_1	0.853	1
X_2	Pre-Test, Webb, Test II, Form B	+ 0.95357 X_2	52.468**	1	- 0.04643 X_2	0.124	1
X_3	Otis, New Edition Gamma Em	+ 0.11951 X_3	2.366	1	+ 0.11951 X_3	2.366	1
	Group - if experimental I	+ 1.06647	2.294	3	+ 1.06647	2.294	3
	- if experimental II	+ 1.30762			+ 1.30762		
	- if control I	- 2.57096			- 2.57096		
	- if control II	+ 0.19687			+ 0.19687		
	Grade level - if ninth	- 0.70161	0.374	3	- 0.70161	0.374	3
	- if tenth	- 0.84935			- 0.84935		
	- if eleventh	- 1.66058			- 1.66058		
	- if twelfth	+ 3.21155			+ 3.21155		
	Sex - if male	+ 0.66064	1.483	1	+ 0.66064	1.483	1
	- if female	- 0.66064			- 0.66064		
	Constant	-14.59949			-14.59949		
	Multiple Correlation R	0.704			0.387		
	Error Variance	30.723			30.723		
	Degrees of Freedom:Error	104			104		

*Significant, five per cent level
**Significant, one per cent level

1. Kuhlmann-Anderson, Form H
2. Pre-Test, Webb, Test II, Form B
3. Otis, New Edition Gamma Em
4. Sex
5. Grade level: ninth, tenth, eleventh, twelfth

The hypothesis of no difference for the four groups cannot be rejected at the 0.05 level, however, it can be rejected at the 0.10 level. Therefore, it may be said that for this end of the year test the difference favoring the experimental groups approaches significance. It should be noted that this difference is in the opposite direction from that of the first semester.

A possible explanation of the reversal from results favoring the control groups the first semester to those favoring the experimental groups the second semester, is that the instructor of the experimental groups suffered a protracted illness and that his classes, taught by an English teacher substitute, failed to complete in the first semester all of the materials covered on the post-test.

Analysis of Percentages for Items

Percentages of change in response from wrong on the pre-test to right on the post-test (W-R) and percentages of responses which were right on the pre-test and remained right on the post-test (R-R) were considered for each group on verbatim and paraphrased items for units three, five, and nine. The sign of the difference between the two percentages for an item were tabulated, a plus sign (+) indicating favor of experimental groups I or II.

Test was made of the hypothesis H_0 that the median of the differences for a unit is zero against the alternative hypothesis H_1 that the median of the differences is positive. The binomial probability $P(x \geq r) = E(n, r, 1/2)$ is the probability that at least r successes will occur in n independent trials (1). Small values of P, that is $P \leq 0.05$, lead to rejection of the hypothesis H_0 and to the acceptance of the alternative H_1 supporting the inference that the experimental group is superior.

A summary of results of sign tests by unit and type of item for comparisons of the control group with experimental groups I and II are shown in Table IX. The Experimental Group II is favored (0.05 level) on the verbatim items for unit nine when the percentage of wrong responses on the pre-test which changed to right on the post-test (W-R) is considered. The Experimental Group I is favored (0.05 level) for paraphrased items for unit three when the percentage of right responses on the pre-test which remained right on the post-test (R-R) is considered. The hypothesis under test cannot be rejected (0.05 level) for the other comparisons.

Summary and Conclusions

The results of the analyses of data from the first semester

TABLE IX

SUMMARY OF RESULTS OF SIGN TESTS BY TYPE OF ITEM AND UNIT FOR COMPARISONS OF CONTROL I GROUP WITH EACH EXPERIMENTAL GROUP, HIGH SCHOOL ALGEBRA

Type of Item	Unit	Group Comparisons	Wrong to Right			Right to Right		
			n	r	P	n	r	P
Verbatim	3	Exp.I - Control I	18	7	0.88106	18	8	0.75966
Verbatim	5	Exp.I - Control I	16	4	0.98936	12	8	0.19385
Verbatim	9	Exp.I - Control I	17	9	0.50000	6	3	0.65625
Verbatim	3	Exp.II - Control I	18	8	0.75966	18	7	0.88106
Verbatim	5	Exp.II - Control I	16	6	0.89494	14	7	0.60474
Verbatim	9	Exp.II - Control I	17	15	0.00117	6	3	0.65625
Paraphrased	3	Exp.I - Control I	17	8	0.68547	18	14	0.01544
Paraphrased	5	Exp.I - Control I	16	9	0.40181	12	5	0.80615
Paraphrased	9	Exp.I - Control I	18	5	0.98456	11	6	0.50000
Paraphrased	3	Exp.II - Control I	17	5	0.97548	18	6	0.95187
Paraphrased	5	Exp.II - Control I	16	10	0.22725	12	8	0.19385
Paraphrased	9	Exp.II - Control I	18	10	0.40726	11	6	0.50000

show significant differences between the experimental and control groups, favoring the control groups. It is believed that this situation was occasioned by the fact that the instructor of the experimental groups became ill at a critical time in the experiment when adjunct auto-instructional exercises were being prepared and the substitute teacher, an English teacher, could not adequately cope with the situation.

The results of the analyses of data from the second semester show rather large but not significant differences between the experimental and control groups. The direction of the difference on the end of year test reversed, however, and favors the experimental groups.

This experiment cannot be regarded as an adequate test of the effectiveness of adjunct auto-instructional exercises in first year high school algebra.

Chapter IV

Junior High School General Science

Purpose

The purpose of the investigation was to test the value of adjunct auto-instructional materials with seventh grade students in a junior high school general science course. A comparison was made between an experimental section using specially prepared adjunct auto-instructional learning exercises and a control section not using those materials. The experimental section of the first semester, with its instructor, became the control section the second semester.

Materials

Materials for the study consisted of a textbook, Scientists at Work, Helen Dolman MacCracken, Donald Gilmore Decker, John Gammons Read and Alton Yarian, reference materials in the areas of chemistry, geology and earth science, 16 mm sound films, 35 mm film strips, and classroom demonstrations and laboratory experiments. The adjunct auto-instructional materials used in the experimental groups were teacher made, three-choice, multiple-choice learning exercises used with Trainer-Tester Response Cards. The learning exercises varied from eight to fifteen items in length.

Subjects

The subjects were sixty-six seventh grade students in two sections of General Science in Flowing Wells Junior High School in Tucson, Arizona. Background information included age, sex, and intelligence quotient as measured by the Lorge-Thorndike Intelligence Test.

Procedure

Sequential Tests of Educational Progress (STEP), Science 3A, were administered to the experimental and the control groups at the beginning of the first semester. Each group studied matter and energy for ten weeks. Classes were 70 minute periods, four days per week. The experimental group used adjunct auto-instructional learning exercises two of these days. These were given during the last part of the period and followed by class discussion. The control group did not use adjunct auto-instructional exercises but spent the same amount of time in individual study. At the end of the first semester STEP, Science 3B, was given as a post-test to each group.

The two groups were reversed in the second semester, the instructors remaining with their respective groups. At the beginning of the second semester a 70 item, teacher constructed, test on the topics of geology and earth science was administered as a pre-test. The experimental group used two adjunct auto-instructional learning exercises each week for ten weeks. The 70 item, teacher constructed, test was given as a post-test at the end of the semester.

Analysis and Results

The problem to be put to test was whether a group using adjunct auto-instruction was more effective in learning course material in junior high school general science than a group taking the same course without the use of such instruction.

The hypothesis of no difference between the experimental and control groups was tested using an analysis of covariance technique with scores of individuals. The scores which provided the basis for statistical tests of group differences were obtained from:

1. Post-test, first semester, STEP, Science 3B
2. Post-test, second semester, a 70 item teacher constructed test used also as the pre-test

The variables considered in covariance for the analyses of first semester scores were:

1. Age in years
2. Sex
3. I.Q. Lorge-Thorndike Intelligence Test, Level 4, Form A, Verbal Battery
4. Pre-test, STEP, Science 3A

The variables considered in covariance for the analyses of second semester scores were:

1. Age in years

TABLE X

MEANS FOR THE EXPERIMENTAL GROUP, THE CONTROL GROUP, AND THE GROUPS MERGED, WITH STANDARD DEVIATIONS FOR THE MERGED GROUPS, GENERAL SCIENCE

	First Semester				Second Semester			
	Means			Std. Dev.	Means			Std. Dev.
	Experimental (N = 32)	Control (N = 34)	Groups Merged (N = 66)	Groups Merged	Experimental (N = 34)	Control (N = 32)	Groups Merged (N = 66)	Groups Merged
Age	12.634	12.512	12.571	0.364	12.512	12.634	12.571	0.364
Lorge-Thorndike Level 4	125.562	127.618	126.621	9.883	127.618	125.562	126.621	9.883
Pre-test STEP Science 3A Tchr Con.	44.875	40.941	42.848	5.216	30.294	35.031	32.591	6.091
Post-test STEP Science 3B Tchr Con.	39.375	36.912	38.106	5.111	40.412	42.812	41.576	5.271

TABLE XI

INTERCORRELATION MATRICES, GENERAL SCIENCE FIRST AND SECOND SEMESTERS (N = 66)

	Semester	2	3	4
1. Age	1	-0.321	-0.014	-0.103
	2	-0.321	0.092	0.145
2. Lorge-Thorndike, Level 4	1		0.116	0.367
	2		0.308	0.095
3. Pre-Test				
STEP Science 3A	1			0.656
Tchr Constructed	2			0.468
4 Post-Test				
STEP Science 3B	1			
Tchr Constructed	2			

Note: r_{05}(d.f. = 60) = 0.250

r_{01}(d.f. = 60) = 0.325

TABLE XII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM GENERAL SCIENCE TESTS (N = 66)

	First Semester			Second Semester		
	Y Post-Test			Y Post-Test		
	Regression Coefficients and Constants With R	Test Statistics F	d.f.	Regression Coefficients and Constants With R	Test Statistics F	d.f.
X_1 Age	$-0.17869 X_1$	0.018	1	$+1.40038 X_1$	0.625	1
X_2 Lorge-Thorndike Level 4	$+0.16198 X_2$	10.449**	1	$+0.00581 X_2$	0.006	1
X_3 Pre-Test STEP Science 3A	$+0.55189 X_3$	25.993**	1			
Tchr Const.				$+0.35736 X_3$	6.571*	1
Sex - if male	+0.40480	0.608	1	+0.28903	0.163	1
- if female	-0.40480			-0.28903		
Groups - if exp.	+0.36146	0.470	1	-0.30352	0.178	1
- if cont.	-0.36146			+0.30352		
Constant	-3.75784			+11.68585		
Multiple Correlation R	0.723			0.482		
Error Variance	13.520			23.094		
Degrees of Freedom: Error	60			60		

*Significant, five per cent level
**Significant, one per cent level

2. Sex

3. I. Q. (Lorge-Thorndike Intelligence Test)

4. Pre-test, second semester, used also as the post-test

Means for the variables considered in the analyses for the experimental group, the control group and the two groups merged are shown for each semester in Table X. Standard deviations are also shown for the two groups merged for each semester. Intercorrelation matrices based on the measurements are presented in Table XI.

The results of the analyses of covariance are given in Table XII. The hypothesis of no difference between groups cannot be rejected for either semester.

Conclusions

It must be inferred from these data that either there is no difference between the experimental and control groups or that the difference is not large enough to show in a sample of this size.

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Chapter V

Human Growth and Learning

In the research reported in the previous chapters immediate knowledge of results has been assumed to be a necessary condition for learning. In using adjunct auto-instructional exercises in educational psychology the question of the necessity of immediate feedback has been raised. Hence, this question became the main focus of the research in the course, Human Growth and Learning.

Studies reporting the superiority of immediate knowledge of results over delayed feedback have appeared with some regularity over the past sixty years. In the last few years studies have been reported which throw some doubt upon the universality of this principle when one considers the type of learning and the different organisms involved. Inferences based on studies of motor tasks do not necessarily yield information about verbal tasks, especially when the verbal tasks are meaningful.

The problem to be put to test in this study was whether there is any difference in retention of meaningful material when the knowledge of results is immediate and when it is delayed. This study used college students who were given knowledge of results on subject matter tests in educational psychology with varying feedback intervals; immediate knowledge, one hour, two day, and one week delay of feedback.

Materials

The materials used in this investigation included four journal articles, four adjunct auto-instructional exercises over the articles, four tests used as retention tests, Trainer-Tester Response Cards, response forms, and delayed feedback forms.

Articles: The four articles (see Appendix D for a sample article) used in this study were:

1. Flesher, Marie A. and Pressey, S. L. "Wartime Accelerates Ten Years After". Reprint fror the J. of Ed. Psychol., 46 #4, April 1955, 228-238. (This article will be referred to as Article A.)

2. Bruner, J. S. and Goodman, C. C. "Value and Need as Organizing Factors in Perception". Published in Readings in the Psychology of Human Growth and Development. New York: Holt, Rinehart, and Winston, Inc., 1962, 216-227 W. R. Baller (Ed). (This article will be referred to as Article B.)

3. Hunter, E. C. "Changes in Teachers' Attitudes Toward Children's Behavior over the Last Thirty Years". Published in Readings in the Psychology of Human Growth and Development. New York: Holt, Rinehart, and Winston, Inc., 1964, 649-657 and W. R. Baller (Ed.) (This article will be referred to as Article C.)

4. Jackson, R. W. and Getzels, J. W. "Dissatisfaction with School Among Adolescents". Published in Readings for Educational Psychology, New York: Harcourt, Brace, and World, Inc., 1964, 124-132, E. B. Page (Ed.) (This article will be referred to as Article D.)

First tests. A test over the content of each article was constructed (Appendix D). Before use in the study, each test was administered to a sample of students other than those used in the experiment, and an item analysis was completed for each item.

Retests. The test for retention (Appendix D) for each article was identical with the first test for the same article, except that the order of items and the alternatives for each item were rearranged.

Response forms. Three types of response forms were used in the study. (Forms 1, 2, and 4). One type was used for the subjects in the sections receiving immediate feedback. This form provided space for one response for each item. A second type was used by subjects receiving feedback after delays of one hour, two days, and one week. This form provided space for two responses for each item. A third type was used by all subjects in the study for response to the retest for each article.

Feedback form. A feedback form provided knowledge of results to the sections receiving the delays of feedback (Form 3). On this form, the correct response for each item is indicated by the typed words "correct response" in the appropriate space for each item. The subject's response on the first test is indicated by the number one or two or both for each item and was written in by the investigator.

Trainer-Tester Response Cards. This card was used by the subjects in the sections receiving immediate feedback (see Appendix E). This 3 x 5 card provides 30 multiple-choice responses using the three-choice format. Each item number has three ink spots representing three possible alternatives. The correct response is indicated by "R" under the ink spot. To determine the correct response, the subject must erase the ink sport to locate the "R" appearing underneath.

Personal Data. The subjects completed a Student Data Sheet, took a Pre-Test covering Educational Psychology, and took the Otis Quick-Scoring Mental Ability Test, Gamma Form.

Subjects

Three hundred forty-seven students were enrolled in eight sections of the course "Human Growth and Learning" (catalog designation Education 151) in the College of Education, University of Arizona, during the first semester 1964-65, and two hundred sixty-seven students enrolled in eight sections the second semester 1964-65. From these students the subjects for the experiment were obtained.

The first semester sample consisted of two hundred fifty-one students who participated in the experiment with Article A, and two hundred-thirty-eight students who participated in the experiment with Article B. During the second semester the study included one hundred ninety-five students who participated in the experiment with Article C, and two hundred one students who participated in the experiment with Article D.

Experimental Treatments

Four experimental groups, each receiving a different treatment, were studied:

Treatment One (T_1) Subjects received immediate feedback.

Treatment Two (T_2) Subjects received feedback after _one hour delay_.

Treatment Three (T_3) Subjects received feedback after a _two-day period_.

Treatment Four (T_4) Subjects received feedback after _one week delay_.

Procedures

The course "Human Growth and Learning" is a six-hour credit course which meets for two hours, three days a week. No special criteria are employed to assign students to a particular section. The sections selected to receive a particular treatment were chosen in such a way as to minimize inconvenience to the instructors.

The investigator and the instructor of each section involved arranged, at least two weeks in advance, the appropriate time for gathering the data. The experiment was initiated during the first hour of the double period. No specific time limit was placed on the reading of the article and taking the test; however, the maximum time needed for any one article was fifty minutes.

At the beginning of each experimental session the investigator gave the necessary instructions and the demonstrations, and answered any question pertinent to the experimental procedure. Each subject in the T_1 groups was then provided a copy of the article to read. The subject read the article and indicated that he had completed the reading by raising his hand. The investigator then picked up the article and gave the subject a test over the article's content, a single choice response form, a Trainer-Tester Response Card, and an eraser. The subject was to indicate his choice of answers on a response form (Form 1) providing for a single answer, and then immediately to erase the appropriate ink spot on the Trainer-Tester Response Card (see Appendix E). If the choice made was incorrect, another choice was made and he received immediate feedback. Specific instructions were given to the subject to answer each item and receive confirmation on that response before answering the next item. One week later, a retest was administered to the subjects.

Sections receiving T_2, T_3, and T_4 followed similar procedures. In these instances a two-choice response form was provided (Form 2), so that for each item on the first test, the subject could indicate two choices. It was not mandatory to make two choices for each item, but the opportunity existed.

For T_2 groups, feedback was provided, after an hour delay, during the last fifteen minutes of the class period. For T_3 and T_4 groups, feedback was provided after a two day delay and one week delay respectively.

In providing feedback for T_2, T_3, and T_4 groups, the feedback form (Form 3) was used. The choices, either one or two, marked

Form 1

Name____________________Section__________Date__________________

Values and Needs

Please make a response to each item. Respond by writing an a, b, or c on the appropriate line.

1. __________________________
2. __________________________
3. __________________________
4. __________________________
5. __________________________
6. __________________________
7. __________________________
8. __________________________
9. __________________________
10. __________________________
11. __________________________
12. __________________________
13. __________________________
14. __________________________
15. __________________________
16. __________________________
17. __________________________
18. __________________________
19. __________________________
20. __________________________
21. __________________________
22. __________________________
23. __________________________
24. __________________________
25. __________________________
26. __________________________
27. __________________________
28. __________________________

Form 2

Name______________________________Section________Date____________________

Value and Needs

Please make a response to __each__ item. If you are __not__ __sure__ of your first choice make a second choice for that item. Respond by writing a, b, or c on the appropriate line.

	1st choice	2nd choice		1st choice	2nd choice
1.			15.		
2.			16.		
3.			17.		
4.			18.		
5.			19.		
6.			20.		
7.			21.		
8.			22.		
9.			23.		
10.			24.		
11.			25.		
12.			26.		
13.			27.		
14.			28.		

Form 3

Name:______________________Section_________Date____________________

Article____

In this class you were earlier asked to read an article and take a multiple choice test. In order to provide test results, the form below is used. For each item, three alternatives a, b, and c were available. The correct response for each item is indicated by the typed words "correct response". Your first and second responses on the test are indicated in red by the numbers 1 and 2, if there were incorrect responses.

	a	b	c
1			correct response
2		correct response	
3	correct response		
4	correct response		
5			correct response
6		correct response	
7			correct response
8	correct response		
9		correct response	
10			correct response
11			correct response
12	correct response		
13		correct response	
14			correct response
15		correct response	

	a	b	c
16		correct response	
17	correct response		
18			correct response
19	correct response		
20		correct response	
21	correct response		
22	correct response		
23			correct response
24			correct response
25	correct response		
26		correct response	
27			correct response
28		correct response	
29			
30			

Form 4

Name____________________________________
Instructor________________________________
Date______________________Hour______________
Test_____________________________________

Write the letter a, b, or c in the space beside each number to indicate what you think the best answer to the question so numbered on the test sheet.

1.__________________
2.__________________
3.__________________
4.__________________
5.__________________
6.__________________
7.__________________
8.__________________
9.__________________
10.__________________
11.__________________
12.__________________
13.__________________
14.__________________
15.__________________
16.__________________
17.__________________
18.__________________
19.__________________
20.__________________
21.__________________
22.__________________
23.__________________
24.__________________
25.__________________
26.__________________
27.__________________
28.__________________
29.__________________
30.__________________

by the subjects on the first test were indicated with red pencil on the feedback form (Form 3). If a subject had chosen answer "a" as his first choice on item one, and a "c" as his second choice, then a "1" would be marked in the space for alternative "a" for item one and a "2" would be marked in the space provided for "c". The correct answer to the item was typed in as "correct response". For T_2 this required that the exercise be scored and the feedback forms be completed during the hour of delay. The feedback form, along with a copy of the first test, was given to the subject. The subject could see what his choices had been and which were correct responses. Fifteen minutes were sufficient for this feedback.

As in treatment one, treatment groups two, three, and four were retested (Form 4) one week after receiving feedback. A retest (Appendix D) and response form (Form 4) were provided to the subjects. Fifteen minutes were sufficient for this phase of the experiment.

The procedures described above were followed for each of the four articles.

Data Analysis

Two kinds of measurements were used for testing the hypothesis of no difference between the groups receiving T_1 and the groups receiving T_2, T_3, and T_4: first, scores for each individual and second, percentages for each item. Both are based on responses to the multiple-choice items of the first tests and retests.

The scores for individuals which provided a basis for statistical tests of treatment differences were obtained from:

1. First test, Article A, number of right responses
2. Retest, Article A, number of right responses
3. First test, Article B, number of right responses
4. Retest, Article B, number of right responses
5. First test, Article C, number of right responses
6. Retest, Article C, number of right responses
7. First test, Article D, number of right responses
8. Retest, Article D, number of right responses
9. Number of wrong responses on each article first test to change to right responses (W-R) on the article retest (gain score)
10. Number of right responses on each article first test to remain right (R-R) on the article retest (gain score)
11. Score for each individual when that individual's first test score is subtracted from his retest score (difference score)

The scores for individuals were subjected to an analysis of covariance using the regression method in order to test the hypothesis of no difference between treatment groups. The variables considered in covariance for the various analyses were:

1. Age, in years
2. Grade Point Average
3. Otis New Edition Gamma Em
4. Hours, Psychology
5. Hours, Behavioral Sciences other than Psychology
6. Pre-test, Course (knowledge of educational psychology)
7. Sex
8. Classification: junior, senior, or other
9. Major Area: elementary, secondary, or other
10. First Test, Articles A, B, C, or D

The percentages computed for each item of the article tests by treatments and considered for statistical analysis are:

1. Percentages of wrong responses on the first tests which changed to right on the retests.

2. Percentage of right responses on the first tests which remained right on the retests.

The sign test (3), a non-parametric test, was used to test the hypothesis of no difference between treatments one, two, three, and four where the percentage for items were considered.

Analysis of Scores for Individuals

The hypotheses of no difference for paired treatments, treatment one (T_1) with treatment two (T_2), treatment one (T_1) with treatment three (T_3), and treatment one (T_1) with treatment four (T_4) are of primary concern and were tested using an analysis of covariance technique with scores for individuals (5).

Articles A, B, C, and D were considered as separate experiments for the statistical analysis. Analyses of covariance by regression methods were carried out to test the hypothesis of no difference between treatment groups for each of the four articles. Data for the statistical tests were retest scores, gain scores (W-R), gain scores (R-R) and difference scores (retest minus first test).

Variables considered in covariance were:

1. Age
2. Grade Point Average
3. Otis New Edition Gamma Em
4. Hours, Psychology
5. Hours, Behavioral Sciences other than Psychology
6. Pre-Test, Course (knowledge of educational psychology)
7. First Test, Article A, B, C, or D
8. Sex
9. Classification: junior, senior, or other
10. Major Area: elementary, secondary, or other

Means for variables in the analysis, computed for T_1, T_2, T_3, and T_4 groups and the treatment groups combined, are shown in Table XIII for Articles A, B, C, and D. Standard deviations for the treatment groups combined, and F ratios are also shown. The F ratios were computed to test the hypothesis of no difference for treatment groups on the variables:

1. Age
2. Grade Point Average
3. Otis New Edition Gamma Em
4. Hours, Psychology
5. Hours, Behavioral Sciences other than psychology
6. Pre-Test, Course (knowledge of educational psychology)

No difference for treatment groups was indicated. The hypothesis can not be rejected (0.05 level) for any of these variables. The values of F computed for the variable, First-Test, for each article are significant (0.01 level) for Article B, and (0.05 level) for Article D.

Means for the following variables:

1. Retest Scores
2. Gain Scores (W-R)
3. Gain Scores (R-R)
4. Difference Scores (Retest minus First Test score)

TABLE XIII

STATISTICS FOR EACH OF THE FOUR TREATMENT GROUPS AND THE GROUPS MERGED WITH F FOR TESTING THE HYPOTHESIS OF NO GROUP DIFFERENCE FOR VARIABLES CONSIDERED IN COVARIANCE, ARTICLES A (N = 251), B (N = 238), C (N = 195), D (N = 201)

	Articles	Means					Std. Deviations	F
		T_1	T_2	T_3	T_4	Groups Merged	Groups Merged	
Age	A	22.197	23.133	23.492	22.985	22.960	0.864	0.392
Age	B	22.839	23.633	23.088	23.000	23.143	6.732	0.153
Age	C	23.362	23.900	21.979	24.634	23.462	6.371	1.419
Age	D	24.260	23.583	23.679	22.520	23.512	6.629	0.595
Grade Point Average	A	2.554	2.534	2.517	2.606	2.553	0.601	0.261
Grade Point Average	B	2.470	2.432	2.598	2.650	2.540	0.576	1.988
Grade Point Average	C	2.665	2.543	2.506	2.548	2.565	0.602	0.614
Grade Point Average	D	2.522	2.607	2.512	2.582	2.555	0.613	0.281
Otis Gamma	A	61.279	61.000	61.785	60.262	61.080	8.728	0.341
Otis Gamma	B	61.321	61.133	60.895	61.662	61.265	8.575	0.086
Otis Gamma	C	62.234	60.017	61.255	59.585	60.759	8.632	0.908
Otis Gamma	D	60.160	61.687	59.528	61.380	60.662	8.825	0.668
Hours, Psychology	A	4.361	4.517	4.862	4.323	4.518	3.556	0.304
Hours, Psychology	B	4.107	4.867	4.193	4.846	4.521	3.602	0.762
Hours, Psychology	C	5.213	4.500	4.447	13.439	4.395	5.513	0.948
Hours, Psychology	D	3.520	5.042	3.604	4.380	4.119	4.469	1.278
Hours, Other Behav. Sci.	A	3.770	3.833	4.000	4.615	4.116	5.006	0.592
Hours, Other Behav. Sci.	B	3.071	3.933	4.702	3.523	3.803	4.407	1.417
Hours, Other Behav. Sci.	C	5.362	5.417	4.809	6.195	5.421	6.395	C.342
Hours, Other Behav. Sci.	D	6.040	6.062	4.208	4.840	5.264	6.212	1.115
Pre-Test, Course	A	28.557	29.050	29.108	28.231	28.733	4.122	0.653
Pre-Test, Course	B	29.161	29.683	28.772	29.077	29.176	4.242	0.467
Pre-Test, Course	C	29.191	29.950	28.170	28.659	29.067	4.773	1.356
Pre-Test, Course	D	29.860	29.562	29.075	28.220	29.174	4.964	1.039
First-Test Article	A	18.590	18.100	17.892	17.785	18.084	1.821	2.439
First-Test Article	B	19.571	19.467	18.684	18.015	18.908	2.946	3.901**
First-Test Article	C	18.362	18.317	17.468	17.829	18.021	2.361	1.256
First-Test, Article	D	14.400	13.625	13.000	13.120	13.527	2.810	2.662*
Retest	A	19.197	19.300	18.800	18.077	18.829	1.731	
Retest	B	16.411	20.083	18.474	17.785	18.206	5.177	
Retest	C	18.638	18.917	18.447	17.634	18.467	2.978	
Retest	D	13.680	15.229	15.868	15.520	15.085	3.263	
Wrong-Right	A	1.607	2.033	2.062	2.077	1.948	1.526	
Wrong-Right	B	3.964	5.150	5.053	5.277	4.874	2.446	
Wrong-Right	C	2.872	3.250	3.596	3.293	3.251	1.919	
Wrong-Right	D	3.820	5.146	5.679	5.200	4.970	2.195	
Right-Right	A	17.541	17.200	16.723	15.985	16.849	2.232	
Right-Right	B	12.411	14.800	13.228	12.400	13.214	4.448	
Right-Right	C	15.766	15.700	14.681	14.415	15.200	3.521	
Right-Right	D	9.900	10.083	10.189	10.200	10.095	3.281	
Retest minus First Test	A	0.607	1.200	0.908	0.292	0.745	2.023	
Retest minus First Test	B	-3.161	0.617	-0.211	-0.263	-0.702	5.503	
Retest minus First Test	C	0.277	0.600	0.979	-0.195	0.446	2.750	
Retest minus First Test	D	-0.720	1.604	2.868	2.400	1.557	3.695	

Note: Degrees of Freedom for F: Article A (3,247), Article B (3,234), Article C (3,191), Article D (3,197).

*Significant, five per cent level
**Significant, one per cent level

computed for T_1, T_2, T_3, and T_4 groups and the groups combined are also shown in Table XIII for Articles A, B, C, and D with the standard deviations for the group combined.

Intercorrelation matrices for Articles A, B, C, and D are shown in Table XIV. The variables included are

1. Age, years
2. Grade Point Average (one is superior, five is failing)
3. Otis New Edition Gamma Em
4. Hours, Psychology
5. Hours, Behavioral Sciences other than Psychology
6. Pre-Test, Course
7. First Test, Article A, B, C, or D
8. Retest, Article A, B, C, or D
9. Gain Score (W-R)
10. Gain Score (R-R)
11. Differences, Retest minus First Test score

The results of the analyses of covariance by regression methods are presented in Tables XV, XVI, XVII, and XVIII for Articles A, B, C, and D respectively. The hypothesis tested is that there is no difference for T_1, T_2, T_3, and T_4 groups as measured by retest, gain, and difference scores on each of the four articles.

A summary of the coefficients of multiple correlation, treatment effects, and the computed values of F for testing the significance of treatment effects on retest scores, is shown in Table XIX. The summary includes results for each of the four articles. The F is significant (0.01 level) for articles A, B, and D. One may, therefore, reject the hypothesis of no difference for T_1, T_2, T_3, and T_4 groups as measured by retest scores on Articles A, B, and D.

TABLE XIV

INTERCORRELATION MATRICES, ARTICLES A(N=251), B(N=238), C(N=195) and D(N=201)

	Articles	2	3	4	5	6	7	8	9	10	11
1. Age	A	-.122	-.117	-.046	-.039	.082	.087	.044	-.095	.084	-.040
	B	-.126	-.093	-.034	-.072	.075	.043	0.84	-.080	.142	.056
	C	-.193	-.127	-.072	-.020	.036	-.008	-.078	- 090	-.019	-.077
	D	-.206	-.099	-.061	.020	.095	.028	-.083	-.133	.012	-.095
2. Grade Point Average	A		-.351	.140	.015	-.297	-.192	-.276	.097	-.283	-.064
	B		-.362	.087	.059	-.252	-.307	-.171	.146	-.263	.004
	C		-.279	-.045	.024	-.155	-.098	-.301	-.081	-.209	-.231
	D		-.258	-.046	.032	-.185	-.216	-.231	.115	-.321	-.039
3. Otis Gamma	A			-.081	.019	.356	.328	.236	-.247	.359	-.093
	B			-.050	-.012	.349	.288	.184	-.083	.256	.019
	C			.124	.121	.367	.322	.488	-.098	.467	.216
	D			.104	.114	.366	.243	.236	-.101	.305	.023
4. Hours, Psychology	A				.002	-.015	-.025	-.112	-.023	-.074	-.073
	B				.058	.023	.026	-.058	-.086	-.026	-.068
	C				.235	.165	.164	.136	-.094	.182	-.011
	D				.206	.125	.063	.040	-.128	.120	-.013
5. Hours, Other Behav. Sci.	A					.129	-.026	-.038	-.056	-.022	-.008
	B					.153	138	.132	-.013	.158	.050
	C					.217	.261	.079	-.170	.171	-.167
	D					.201	.190	-.000	-.069	.045	-.145
6. Pre-Test, Course	A						.193	.208	-.158	.273	.004
	B						.231	.165	-.094	.224	.032
	C						.358	.355	-.235	.438	.038
	D						.192	.145	-.104	.236	-.018
7. First Test, Article	A							.352	-.790	.825	-.599
	B							.170	-.513	.490	-.375
	C							.529	-.616	.798	-.395
	D							.266	-.649	.718	-.525
8. Retest, Article	A								.060	.718	.539
	B								.483	.877	.849
	C								.032	.824	.571
	D								.337	.764	.680
9. Wrong-Right	A									-.634	.762
	B									.023	.729
	C									-.525	.631
	D									-.337	.791
10. Right-Right	A										-.128
	B										.563
	C										.120
	D										.128
11. Difference, Retest Minus First Test	A										
	B										
	C										
	D										

Note: r_{05}(d.f. = 200) = 0.138, r_{01}(d.f. = 200) = 0.181

r_{05}(d.f. = 150) = 0.159, r_{01}(d.f. = 150) = 0.208

TABLE XV

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE A (N = 251)

		Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
		Regression Coefficients and Constants	Test Statistic		Regression Coefficients and Constants	Test Statistic		Regression Coefficients and Constants	Test Statistic		Regression Coefficients and Constants	Test Statistic	
		With R	F	d. f.	With R	F	d. f.	With R	F	d. f.	With R	F	d. f.
X_1	Age	$-0.00129 X_1$	0.006	1	$-0.00941 X_1$	0.833	1	$+0.00400 X_1$	0.095	1	$-0.00129 X_1$	0.006	1
X_2	Grade Point Average	$-0.46656 X_2$	6.130*	1	$-0.14077 X_2$	1.494	1	$-0.31717 X_2$	4.763*	1	$-0.46656 X_2$	6.130*	1
X_3	Otis Gamma	$+0.00967 X_3$	0.522	1	$-0.00126 X_3$	0.024	1	$+0.01057 X_3$	1.049	1	$0.00967 X_3$	0.522	1
X_4	Hours, Psychology	$-0.02712 X_4$	0.830	1	$-0.01686 X_4$	0.859	1	$-0.01475 X_4$	0.412	1	$-0.02712 X_4$	0.830	1
X_5	Hours, Other Behav. Sci.	$-0.00376 X_5$	0.031	1	$-0.02479 X_5$	3.568	1	$+0.00632 X_5$	0.146	1	$-0.00376 X_5$	0.031	1
X_6	Pre-Test, Course	$+0.02745 X_6$	1.018	1	$-0.00778 X_6$	0.219	1	$+0.04136 X_6$	3.887	1	$+0.02745 X_6$	1.018	1
X_7	First-Test, Article A	$+0.25015 X_7$	17.899**	1	$-0.66556 X_7$	0.034	1	$+0.93467 X_7$	0.042	1	$-0.74985 X_7$	0.106	1
	Treatment - if T_1	+0.21157	5.435**	3	-0.01584	0.355	3	+0.19380	5.623**	3	+0.21157	5.435**	3
	- if T_2	+0.44552			+0.10354			+0.30540			+0.44552		
	- if T_3	-0.00500			-0.01731			+0.02935			-0.00500		
	- if T_4	-0.65208			-0.07039			-0.52854			-0.65208		
	Sex - if male	-0.03085	0.060	1	-0.04863	0.399	1	-0.00201	0.000	1	-0.03085	0.060	1
	- if female	+0.03085			+0.04863			+0.00201			+0.03085		
	Classification - if junior	+0.03721	0.139	2	-0.04319	0.096	2	+0.05874	0.197	2	+0.03721	0.139	2
	- if senior	-0.11697			+0.03867			-0.09326			-0.11697		
	- if other	+0.07976			+0.00452			+0.03453			+0.07976		
	Major Area - if elementary	-0.22157	1.377	2	-0.16048	0.585	2	+0.03880	0.937	2	-0.22157	1.377	2
	- if secondary	+0.15639			-0.06154			+0.23359			+0.15639		
	- if other	+0.06518			+0.22202			-0.27239			+0.06518		
	Constant	+14.28864			+15.15122			-1.28612			+14.28864		
	Multiple Correlation R	0.500			0.800			0.855			0.671		
	Error Variance	2.393			0.894			1.423			2.393		
	Degrees of Freedom: Error	235			235			235			235		

*Significant, five per cent level
**Significant, one per cent level

TABLE XVI

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE B (N = 238)

		Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
		Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.	Regression Coefficients and Constants With R	Test Statistic F	d.f.
X_1	Age	+0.04751 X_1	0.687	1	-0.02432 X_1	1.022	1	+0.07270 X_1	2.756	1	+0.04751 X_1	0.687	1
X_2	Grade Point Average	-0.61035 X_2	0.853	1	+0.13075 X_2	0.222	1	-0.59621 X_2	1.394	1	-0.61035 X_2	0.853	1
X_3	Otis Gamma	+0.07298 X_3	2.754	1	+0.01925 X_3	1.087	1	+0.05735 X_3	2.912	1	+0.07298 X_3	2.754	1
X_4	Hours, Psychology	-0.12443 X_4	1.688	1	-0.08132 X_4	4.088*	1	-0.05862 X_4	0.641	1	-0.12443 X_4	1.688	1
X_5	Hours, Other Behav. Sci.	+0.09405 X_5	1.300	1	-0.00075 X_5	0.000	1	+0.09385 X_5	2.216	1	+0.09405 X_5	1.300	1
X_6	Pre-Test, Course	+0.07251 X_6	0.720	1	+0.00013 X_6	0.000	1	+0.05115 X_6	0.614	1	+0.07251 X_6	0.720	1
X_7	Pre-Test, Article B	+0.15543 X_7	1.622	1	-0.43734 X_7	72.839**	1	+0.61987 X_7	44.176**	1	-0.84457 X_7	47.892**	1
	Treatment - if T_1	-1.87361	5.041**	3	-0.62428	3.313*	3	-1.14652	3.474*	3	-1.87361	5.041**	3
	- if T_2	+1.72068			+0.59374			+1.11599			+1.72068		
	- if T_3	+0.20971			-0.08165			+0.17426			+0.20971		
	- if T_4	-0.05677			+0.11217			-0.14373			-0.05677		
	Sex - if male	+0.02622	0.004	1	-0.14162	0.007	1	+0.21408	0.461	1	+0.02622	0.004	1
	- if female	-0.02622			+0.14162			-0.21408			-0.02622		
	Classification - if junior	+0.09978	0.219	2	+0.00912	1.076	2	+0.02096	0.009	2	+0.09978	0.219	2
	- if senior	-0.51082			-0.48626			+0.07531			-0.51082		
	- if other	+0.41104			+0.47713			-0.09627			+0.41104		
	Major Area - if elementary	-0.32257	0.590	2	-0.37612	2.066	2	+0.18519	0.287	2	-0.32257	0.590	2
	- if secondary	-0.81052			-0.64101			-0.24418			-0.81052		
	- if other	+1.13309			+1.01713			+0.05899			+1.13309		
	Constant	+9.79311			+12.97758			-3.68996			+9.79311		
	Multiple Correlation R	0.387			0.573			0.572			0.497		
	Error Variance	24.331			4.290			14.208			24.331		
	Degrees of Freedom:Error	222			222			222			222		

*Significant, five per cent level
**Significant, one per cent level

TABLE XVII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE C (N = 195)

	Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
	Regression Coefficients and Constants With R	Test Statistic		Regression Coefficients and Constants With R	Test Statistic		Regression Coefficients and Constants With R	Test Statistic		Regression Coefficients and Constants With R	Test Statistic	
		F	d.f.		F	d.f.		F	d.f.		F	d.f.
X_1 Age	$-0.03508\ X_1$	1.265	1	$-0.03166\ X_1$	2.367	1	$-0.00864\ X_1$	0.105	1	$-0.03508\ X_1$	1.265	1
X_2 Grade Point Average	$-0.76215\ X_2$	5.924*	1	$-0.43945\ X_2$	4.526*	1	$-0.34484\ X_2$	1.654	1	$-0.76215\ X_2$	5.924*	1
X_3 Otis Gamma	$+0.09761\ X_3$	16.823**	1	$+0.02100\ X_3$	1.790	1	$+0.07311\ X_3$	12.873**	1	$+0.09761\ X_3$	16.823**	1
X_4 Hours, Psychology	$+0.01050\ X_4$	0.111	1	$-0.00103\ X_4$	0.002	1	$+0.01987\ X_4$	0.541	1	$+0.01050\ X_4$	0.111	1
X_5 Hours, Other Behav. Sci.	$-0.04218\ X_5$	2.116	1	$-0.00636\ X_5$	0.110	1	$-0.03342\ X_5$	1.813	1	$-0.04218\ X_5$	2.116	1
X_6 Pre-Test, Course	$+0.04413\ X_6$	1.116	1	$-0.02832\ X_6$	1.056	1	$+0.07866\ X_6$	4.835**	1	$+0.04413\ X_6$	1.116	1
X_7 First Test, Article C	$+0.44759\ X_7$	40.944**	1	$-0.45260\ X_7$	96.212**	1	$+0.91385\ X_7$	0.023	1	$-0.55241\ X_7$	62.364**	1
Treatment - if T_1	+0.00129	1.202	3	-0.19492	0.539	3	+0.19156	0.817	3	+0.00129	1.202	3
- if T_2	+0.36389			+0.18389			+0.20937			+0.36389		
- if T_3	+0.14806			+0.02753			-0.03525			+0.14806		
- if T_4	-0.51324			-0.01650			-0.36568			-0.51324		
Sex - if male	-0.22444	1.269	1	+0.06450	0.241	1	-0.24424	2.050	1	-0.22444	1.269	1
- if female	+0.22444			-0.06450			+0.24424			+0.22444		
Classification - if junior	-0.25090	0.439	2	-0.05641	0.964	2	-0.18808	0.550	2	-0.25090	0.439	2
- if senior	+0.22379			+0.32048			-0.17723			+0.22379		
- if other	+0.02711			-0.26408			+0.36531			+0.02711		
Major Area - if elementary	-0.02589	0.310	2	-0.00728	0.131	2	+0.02554	0.073	2	-0.02589	0.310	2
- if secondary	-0.20633			-0.08863			-0.08313			-0.20633		
- if other	+0.23222			+0.09591			+0.05758			+0.23222		
Constant	+6.31325			+12.92954			-6.73382			+6.31325		
Multiple Correlation R	0.677			0.657			0.846			0.604		
Error Variance	5.209			2.267			3.819			5.209		
Degrees of Freedom: Error	179			179			179			179		

*Significant, five per cent level

**Significant, one per cent level

TABLE XVIII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE D (N = 201)

	Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
	Regression Coefficients and Constants With R	Test Statistic F	d. f.	Regression Coefficients and Constants With R	Test Statistic F	d. f.	Regression Coefficients and Constants With R	Test Statistic F	d. f.	Regression Coefficients and Constants With R	Test Statistic F	d. f.
X_1 Age	-0.02898 X_1	0.579	1	-0.03116 X_1	2.271	1	+0.00333 X_1	0.014	1	-0.02898 X_1	0.579	1
X_2 Grade Point Average	-0.92540 X_2	5.862*	1	-0.27196 X_2	1.717	1	-0.72042 X_2	6.708*	1	-0.92540 X_2	5.862*	1
X_3 Otis Gamma	+0.03446 X_3	1.501	1	+0.00613 X_3	0.161	1	+0.02579 X_3	1.588	1	+0.03446 X_3	1.501	1
X_4 Hours, Psychology	-0.00691 X_4	0.020	1	-0.06163 X_4	5.365*	1	+0.04940 X_4	1.919	1	-0.00691 X_4	0.020	1
X_5 Hours, Other Behav. Sci.	+0.01375 X_5	0.135	1	+0.04959 X_5	5.946*	1	-0.03750 X_5	1.893	1	+0.01375 X_5	0.135	1
X_6 Pre-Test, Course	+0.04507 X_6	0.837	1	+0.00981 X_6	0.134	1	+0.04882 X_6	1.853	1	+0.04507 X_6	0.837	1
X_7 First Test, Article D	+0.27412 X_7	11.321**	1	-0.51252 X_7	0.013	1	+0.80502 X_7	0.018	1	-0.72588 X_7	79.387**	1
Treatment - if T_1	-1.58799	6.473**	3	-0.70219	4.792**	3	-0.84295	3.750*	3	-1.58799	6.473**	3
- if T_2	+0.22863			+0.30343			-0.04306			+0.22863		
- if T_3	+0.87315			+0.42682			+0.45829			+0.87315		
- if T_4	+0.48621			-0.02806			+0.42772			+0.48621		
Sex - if male	-0.13283	0.275	1	+0.04406	0.103	1	-0.17381	0.890	1	-0.13283	0.275	1
- if female	+0.13283			-0.04406			+0.17381			+0.13283		
Classification - if junior	+0.74286	2.469	2	+0.45006	2.754	2	+0.37076	1.220	2	+0.74286	2.469	2
- if senior	-0.76024			-0.40146			-0.40027			-0.76024		
- if other	+0.01737			-0.04859			+0.02951			+0.01737		
Major Area - if elementary	-0.43146	1.174	2	-0.04563	4.597*	2	-0.37749	1.018	2	-0.43146	1.174	2
- if secondary	+0.35843			+0.17622			+0.13047			+0.35843		
- if other	+0.07303			-0.13059			+0.24702			+0.07303		
Constant	+10.42824			+12.32838			-2.25703			+10.42824		
Multiple Correlation R	0.507			0.718			0.781			0.648		
Error Variance	8.556			2.523			4.532			8.556		
Degrees of Freedom: Error	185			185			185			185		

*Significant, five per cent level
**Significant, one per cent level

TABLE XIX

SUMMARY OF MULTIPLE CORRELATIONS, TREATMENT EFFECTS, AND F RATIOS FOR TREATMENT EFFECTS ON RETEST SCORES

Article	Multiple Correlation R	Treatments	N	Effects	F
A	0.500	T_1	61	+0.21156	5.435**
		T_2	60	+0.44552	
		T_3	65	-0.00500	
		T_4	65	-0.65208	
B	0.387	T_1	56	-1.87361	5.041**
		T_2	60	+1.72068	
		T_3	57	+0.20971	
		T_4	65	-0.05677	
C	0.677	T_1	47	+0.00129	1.202
		T_2	60	+0.36389	
		T_3	47	+0.14806	
		T_4	41	-0.51324	
D	0.507	T_1	50	-1.58799	6.473**
		T_2	48	+0.22863	
		T_3	53	+0.87315	
		T_4	50	+0.48621	

*Significant, five per cent level
**Significant, one per cent level

The hypothesis of no difference as measured by gain scores (W-R) was also tested for T_1, T_2, T_3, and T_4 groups. A summary of the results is presented in Table XX. One may reject the hypothesis of no difference for T_1, T_2, T_3, and T_4 groups as measured by gain scores (W-R) from Articles B and D. The computed values of F for testing the significance of treatment effects on gain scores (W-R) were significant (0.01 level) for Article D, and significant (0.05 level) for Article B.

A test of the hypothesis of no difference as measured by gain scores (R-R) was also made for T_1, T_2, T_3, and T_4 groups. A summary of the results is shown in Table XXI. The hypothesis may be rejected (0.05 level) for Articles B, D and (0.01 level) for Article A.

Using the difference scores for individuals, the hypothesis of no difference for T_1, T_2, T_3, and T_4 groups were tested. A summary of the results is shown in Table XXII. The comments concerning the treatment effects on retest scores also apply to the treatment effects on difference scores.

Another hypothesis tested in connection with each analysis of scores is that the coefficients for the covariates

1. Age
2. Sex
3. Otis New Edition Gamma Em
4. Hours, Psychology
5. Hours, Behavioral Sciences other than Psychology
6. Classification: junior, senior, or other

TABLE XX

SUMMARY OF MULTIPLE CORRELATIONS, TREATMENT EFFECTS, AND F RATIOS FOR TREATMENT EFFECTS ON GAIN SCORES (W-R)

Article	Multiple Correlation R	Treatments	N	Effects	F
A	0.800	T_1	61	-0.01583	0.355
		T_2	60	+0.10354	
		T_3	65	-0.01731	
		T_4	65	-0.07039	
B	0.573	T_1	56	-0.62426	3.313*
		T_2	60	+0.59374	
		T_3	57	-0.08165	
		T_4	65	+0.11217	
C	0.657	T_1	47	-0.19492	0.539
		T_2	60	+0.18389	
		T_3	47	+0.02753	
		T_4	41	-0.01650	
D	0.718	T_1	50	-0.70219	4.792**
		T_2	48	+0.30343	
		T_3	53	+0.42682	
		T_4	50	-0.02806	

*Significant, five per cent level
**Significant, one per cent level

TABLE XXI

SUMMARY OF MULTIPLE CORRELATIONS, TREATMENT EFFECTS AND F RATIOS FOR TREATMENT EFFECTS ON GAIN SCORES (R-R)

Article	Multiple Correlation R	Treatments	N	Effects	F
A	0.855	T_1	61	+0.19380	5.623**
		T_2	60	+0.30540	
		T_3	65	+0.02935	
		T_4	65	-0.52854	
B	0.572	T_1	56	-1.14652	3.474*
		T_2	60	+1.11599	
		T_3	57	+0.17526	
		T_4	65	-0.14373	
C	0.846	T_1	47	+0.19156	0.817
		T_2	60	+0.20937	
		T_3	47	-0.03525	
		T_4	41	-0.36568	
D	0.781	T_1	50	-0.84295	3.750*
		T_2	48	-0.04306	
		T_3	53	+0.45829	
		T_4	50	+0.42772	

*Significant, five per cent level
**Significant, one per cent level

TABLE XXII

SUMMARY OF MULTIPLE CORRELATIONS, TREATMENT EFFECTS AND F RATIOS FOR TREATMENT EFFECTS ON DIFFERENCE SCORES (Retest minus First Test)

Article	Multiple Correlation R	Treatments	N	Effects	F
		T_1	61	+0.21157	
		T_2	60	+0.44552	
A	0.671	T_3	65	-0.00500	5.435**
		T_4	65	-0.65208	
		T_1	56	-1.87361	
		T_2	60	+1.72068	
B	0.497	T_3	57	+0.20971	5.041**
		T_4	65	-0.05677	
		T_1	47	+0.00129	
		T_2	60	+0.36389	
C	0.604	T_3	47	+0.14806	1.202
		T_4	41	-0.51324	
		T_1	50	-1.58799	
		T_2	48	+0.22863	
D	0.648	T_3	53	+0.87316	6.473**
		T_4	50	+0.48621	

*Significant, five per cent level
**Significant, one per cent level

7. Major Areas: elementary, secondary, or other

in the regression equation, when considered in combination are not significantly different from zero. The results of the computations carried out to test the hypothesis are given in Tables XXIII, XXIV, XXV, and XXVI for Articles A, B, C, and D respectively. A summary of the F ratios:

Article	Dependent Variable	F
A	Retest Scores	0.649
A	Gain Scores (W-R)	0.746
A	Gain Scores (R-R)	0.555
A	Difference Scores	0.649
B	Retest Scores	0.953
B	Gain Scores (W-R)	1.392
B	Gain Scores (R-R)	1.102
B	Difference Scores	0.953
C	Retest Scores	2.872**
C	Gain Scores (W-R)	0.980
C	Gain Scores (R-R)	2.338*
C	Difference Scores	2.872**
D	Retest Scores	1.383
D	Gain Scores (W-R)	2.254
D	Gain Scores (R-R)	1.404
D	Difference Scores	1.383

The hypothesis of no difference between paired treatment effects was tested for each of the sixteen analyses. The hypothesis cannot be rejected for the paired effects from Article C. A summary of treatment effects and treatment effect differences is presented in Table XXVII for the analyses involving retest scores. Tables XXVIII, XXIX, and XXX contain similar summaries for analyses involving gain scores (W-R), (R-R), and Difference

TABLE XXIII

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE A TESTING AN ADDITIONAL MULTIPLE HYPOTHESIS (N = 251)

	Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
	Regression Coefficient and Constants with R	Test Statistic		Regression Coefficient and Constants with R	Test Statistic		Regression Coefficient and Constants with R	Test Statistic		Regression Coefficient and Constants with R	Test Statistic	
		F	d.f.		F	d.f.		F	d.f.		F	d.f.
X_2 Grade Point Average	$-0.54349 X_2$	10.061**	1	$-0.15800 X_2$	2.269	1	$-0.38296 X_2$	8.430**	1	$-0.54349 X_2$	10.061**	1
X_6 Pre-Test, Course	$+0.03536 X_6$	1.993	1	$-0.00918 X_6$	0.359	1	$+0.04579 X_6$	5.641*	1	$+0.03536 X_6$	1.993	1
X_7 First Test, Article A	$+0.26048 X_7$	21.776**	1	$-0.66976 X_7$	384.129**	1	$+0.94730 X_7$	486.023**	1	$-0.73952 X_7$	175.526**	1
Treatment - if T_1	+0.23033			-0.00573			+0.21140			+0.23033		
- if T_2	+0.43350			+0.09427			+0.30489			+0.43350		
- if T_3	-0.02402			-0.00189			+0.01532			-0.02402		
- if T_4	-0.63981			-0.06966			-0.53161			-0. 3981		
Constant	+14.50213			+14.72891			-0.61066			+14.50213		
Multiple Correlation R	0.481			0.793			0.852			0.661		
Error Variance	2.362			0.885			1.400			2.362		
Degrees of Freedom: Error	244			244			244			244		
Multiple Hypothesis		0.649	9		0.746	9		0.555	9		0.649	9
Degrees of Freedom:Error			235			235			235			235

Note: Variables included in the multiple hypothesis are:

X_1	Age
X_3	Otis Gamma
X_4	Hours, Psychology
X_5	Hours, Other Behavioral Sciences
	Sex
	Classification
	Major Area

*Significant, five per cent level

**Significant one per cent level

TABLE XXIV

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE B TESTING AN ADDITIONAL MULTIPLE HYPOTHESIS (N = 238)

	Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
	Regression Coefficients and Constants with R	Test Statistic		Regression Coefficients and Constants with R	Test Statistic		Regression Coefficient and Constants with R	Test Statistic		Regression Coefficient and Constants with R	Test Statistic	
		F	d.f.		F	d.f.		F	d.f.		F	d.f.
X_2 Grade Point Average	-0.94663 X_2	2.502	1	-0.02557 X_2	0.010	1	-0.78575 X_2	2.934	1	-0.94663 X_2	2.502	1
X_6 Pre-Test, Course	+0.12603 X_6	2.529	1	+0.01015 X_6	0.092	1	+0.09477 X_6	2.435	1	+0.12603 X_6	2.529	1
X_7 First Test, Article B	+0.21034 X_7	3.188	1	-0.42680 X_7	73.191**	1	+0.66393 X_7	54.075**	1	-0.78966 X_7	44.931**	1
Treatment - if T_1	-1.97361			-0.61763			-1.24692			-1.97361		
- if T_2	+1.61905			+0.51710			+1.09670			+1.61905		
- if T_3	+0.44602			+0.06418			+0.26109			+0.44602		
- if T_4	-0.09146			+0.03635			-0.11087			-0.09146		
Constant	+12.93084			+12.70214			-0.12334			+12.93084		
Multiple Correlation R	0.342			0.539			0.545			0.467		
Error Variance	24.287			4.355			14.265			24.287		
Degrees of Freedom:Error	231			231			231			231		
Multiple Hypothesis		0.953	9		1.393	9		1.103	9		0.953	9
Degrees of Freedom:Error			222			222			222			222

Notes: Variables included in the multiple hypothesis are:

X_1	Age
X_3	Otis Gamma
X_4	Hours, Psychology
X_5	Hours, Other Behavioral Sciences
	Sex
	Classification
	Major Area

*Significant, five per cent level
**Significant, one per cent level

TABLE XXV

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE C TESTING AN ADDITIONAL MULTIPLE HYPOTHESIS (N = 195)

	Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
	Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.
X_2 Grade Point Average	-1.15255 X_2	15.843**	1	-0.45231 X_2	6.116*	1	-0.68250 X_2	7.760**	1	-1.15255	15.843**	1
X_6 Pre-Test, Course	+0.09629 X_6	6.109*	1	-0.01624 X_6	0.436	1	+0.11558 X_6	12.296**	1	+0.09629	6.109*	1
X_7 First Test, Article C	+0.50188 X_7	52.422**	1	-0.44246 X_7	102.125**	1	+0.96003 X_7	267.933**	1	-0.49812	51.640**	1
Treatment - if T_1	+0.14003			-0.16948			+0.31537			+0.14003		
- if T_2	+0.22769			+0.14552			+0.10525			+0.22769		
- if T_3	+0.31234			+0.07012			+0.09762			+0.31234		
- if T_4	-0.68007			-0.04615			-0.51844			-0.68007		
Constant	+9.54354			+12.84560			-3.73245			+9.54354		
Multiple Correlation R	0.616			0.636			0.826			0.523		
Error Variance	5.676			2.265			4.064			5.676		
Degrees of Freedom:Error	188			188			188			188		
Multiple Hypothesis		2.872**	9		0.980	9		2.338*	9		2.872**	9
Degrees of Freedom:Error			179			179			179			179

Note: Variables included in the multiple hypothesis are:

X_1 Age
X_3 Otis Gamma
X_4 Hours, Psychology
X_5 Hours, Other Behavioral Sciences
Sex
Classification
Major Area

*Significant, five per cent level
** Significant, one per cent level

TABLE XXVI

RESULTS OF ANALYSES OF COVARIANCE OF SCORES FROM TESTS BASED ON ARTICLE D TESTING AN ADDITIONAL MULTIPLE HYPOTHESIS (N = 201)

		Y Retest			Y Wrong to Right			Y Right to Right			Y Difference		
		Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.	Regression Coefficients and Constants with R	Test Statistic F	d.f.
X_2	Grade Point Average	$-0.84592 X_2$	5.713*	1	$-0.06443 X_2$	0.108	1	$-0.82818 X_2$	10.330**	1	$-0.84592 X_2$	5.713*	1
X_6	Pre-Test, Course	$+0.05981 X_6$	1.886	1	$+0.01049 X_6$	0.189	1	$+0.06096 X_6$	3.655	1	$+0.05981 X_6$	1.886	1
X_7	First Test, Article D	$+0.32214 X_7$	16.878**	1	$-0.48519 X_7$	124.880**	1	$+0.82174 X_7$	207.153**	1	$-0.67786 X_7$	74.731**	1
	Treatment - if T_1	-1.74169			-0.73149			-0.97213			-1.74169		
	- if T_2	+0.14692			+0.22692			-0.06333			+0.14692		
	- if T_3	+0.93543			+0.45605			+0.50626			+0.93543		
	- if T_4	+0.65933			+0.04852			+0.52920			+0.65933		
	Constant	+11.13058			+11.38760			-0.69226			+11.13058		
	Multiple Correlation R	0.455			0.680			0.764			0.618		
	Error Variance	8.708			2.670			4.617			8.708		
	Degrees of Freedom:Error	194			194			194			194		
	Multiple Hypothesis		1.383	9		2.256*	9		1.404	9		1.383	9
	Degrees of Freedom:Error			185			185			185			185

Note: Variables included in the multiple hypothesis are:

X_1 Age
X_3 Otis Gamma
X_4 Hours, Psychology
X_5 Hours, Other Behavioral Sciences
Sex
Classification
Major Area

*Significant, five per cent level
**Significant, one per cent level

TABLE XXVII

ESTIMATED TREATMENT EFFECTS ON RETEST SCORES AND TREATMENT EFFECT DIFFERENCES (Absolute Values)

			T_1	T_2	T_3	T_4
	A		0.21157	0.44552	-0.00500	-0.65208
	B		-1.87361	1.72068	0.20971	-0.05677
	C		0.00129	0.36389	0.14806	-0.51324
	D		-1.58799	0.22863	0.87315	0.48621
T_1	A	0.21157		0.23395	0.21657	0.86365**
	B	-1.87361		3.59429**	2.08332*	1.81684*
	C	0.00129		0.36260	0.14677	0.51453
	D	-1.58799		1.81662**	2.46114	2.07420**
T_2	A	0.44552			0.45052	1.09760**
	B	1.72068			1.51097	1.77745*
	C	0.36389			0.21583	0.87713
	D	0.22863			0.64452	0.25758
T_3	A	-0.00500				0.64708**
	B	0.20971				0.26648
	C	0.14806				0.66130
	D	0.87315				0.38694
T_4	A	-0.65208				
	B	-0.05677				
	C	-0.51324				
	D	0.48621				

*Significant, five per cent level
**Significant, one per cent level

TABLE XXVIII

ESTIMATED TREATMENT EFFECTS ON W-R GAIN SCORES AND TREATMENT EFFECT DIFFERENCES (Absolute Values)

			T_1	T_2	T_3	T_4
	A		-0.01584	0.10354	-0.01731	-0.07039
	B		-0.62426	0.59374	-0.08165	0.11217
	C		-0.19492	0.18389	0.02753	-0.01650
	D		-0.70219	0.30343	0.42682	-0.02806
T_1	A	-0.01584		0.11938	0.00147	0.05455
	B	-0.62426		1.21800**	0.54261	0.73643*
	C	-0.19492		0.37881	0.22245	0.17842
	D	-0.70219		1.00562**	1.12901**	0.67413*
T_2	A	0.10354			0.12085	0.17393
	B	0.59374			0.67539	0.48157
	C	0.18389			0.15636	0.20039
	D	0.30343			0.12339	0.33149
T_3	A	-0.01731				0.05308
	B	-0.08165				0.19382
	C	0.02753				0.04403
	D	0.42682				0.45488
T_4	A	-0.07039				
	B	0.11217				
	C	-0.01650				
	D	-0.02806				

*Significant, five per cent level
**Significant, one per cent level

TABLE XXIX

ESTIMATED TREATMENT EFFECTS ON R-R GAIN SCORES AND TREATMENT EFFECT DIFFERENCES (Absolute Values)

			T_1	T_2	T_3	T_4
	A		0.19380	0.30540	0.02935	-0.52854
	B		-1.14652	1.11599	0.17426	-0.14373
	C		0.19156	0.20937	-0.03525	-0.36568
	D		-0.84295	-0.04306	0.45829	0.42772
T_1	A	0.19380		0.11160	0.16445	0.72234**
	B	-1.14652		2.26251**	1.32078*	1.00279
	C	0.19156		0.01781	0.22681	0.55724
	D	-0.84295		0.79989	1.30124**	1.27067**
T_2	A	0.30540			0.27605	0.83394**
	B	1.11599			0.94173	1.25972
	C	0.20937			0.24462	0.57505
	D	-0.04306			0.50135	0.47078
T_3	A	0.02935				0.55789**
	B	0.17426				0.31799
	C	-0.03525				0.33043
	D	0.45829				0.03057
T_4	A	-0.52854				
	B	-0.14373				
	C	-0.36568				
	D	0.42772				

*Significant, five per cent level
**Significant, one per cent level

TABLE XXX

ESTIMATED TREATMENT EFFECTS ON DIFFERENCE SCORES AND TREATMENT EFFECT DIFFERENCES (Absolute Values)

			T_1	T_2	T_3	T_4
	A		0.21157	0.44552	-0.0500	-0.65208
	B		-1.87361	1.72068	0.20971	-0.05677
	C		0.00129	0.36389	0.14806	-0.51324
	D		-1.58799	0.22863	0.87315	0.48621
T_1	A	0.21157		0.23395	0.21657	0.86365**
	B	-1.87361		3.59429**	2.08332*	1.81684*
	C	0.00129		0.36260	0.14677	0.51453
	D	-1.58799		1.81662**	2.46114	2.07420**
T_2	A	0.44552			0.45052	1.09760**
	B	1.72068			1.51097	1.77745*
	C	0.36389			0.21583	0.87713
	D	0.22863			0.64452	0.25758
T_3	A	-0.00500				0.64708**
	B	0.20971				0.26648
	C	0.14806				0.66130
	D	0.87315				0.38694
T_4	A	-0.65208				
	B	-0.05677				
	C	-0.51324				
	D	0.48621				

*Significant, five per cent level
**Significant, one per cent level

Scores respectively.

Analysis of Percentages for Items for Each Article

Percentages of changes in response from wrong on the first test to right on the retest (W-R) and responses which were right on the first test and remained right on the retest (R-R) are shown in Tables XXXI through XLII for all items for each of the four articles, A, B, C, and D.

Analyses of percentages for these changes were made between groups T_1 and T_2, T_1 and T_3, and T_1 and T_4. Tabulation of the sign of the difference between the two percentages for each item was completed and shown. Percentages for T_2, T_3, and T_4, which are equal to or greater than T_1 are classified as plus (+), and a minus (-) signifies a difference in favor of T_1.

Test was made of the hypothesis (H_0) that the median of the differences between paired percentages is equal to zero against the alternative (H_1) that the difference is not zero. The number of positive differences was tabulated. For each treatment comparison the binomial probability (Tables of the Cumulative Binomial Probability Distribution, 1959) $P(x \geq r) = E(n, r, 1/2)$ is the probability that at least r successes will occur in n independent trails. Large values of P, $P \geq 0.975$, and small values of P, $P \geq 0.25$, lead to rejection of the hypothesis (H_0).

A summary of the binomial probabilities of the comparisons of treatments for Articles A, B, C, and D is shown in Table XLIII. When

TABLE XXXI

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE A, $T_2 - T_1$

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_2	T_1 (N = 61)	T_2 (N = 60)	Sign of Diff	T_1	T_2	T_1 (N = 61)	T_2 (N = 60)	Sign of Diff
1	0	2	------	100.00		61	58	100.00	100.00	+
2	7	9	85.71	77.78	-	54	51	94.44	92.16	-
3	1	0	100.00	------		60	60	100.00	98.33	-
4	7	11	71.43	90.91	+	54	49	96.30	100.00	+
5	1	5	100.00	60.00	-	60	55	100.00	96.36	-
6	7	4	85.71	50.00	-	54	56	100.00	98.21	-
7	2	4	100.00	100.00	+	59	56	86.44	100.00	+
8	4	6	25.00	66.67	+	57	54	98.25	96.30	-
9	13	12	53.85	83.33	+	48	48	85.42	79.17	-
10	4	0	75.00	------		57	60	100.00	98.33	-
11	2	10	50.00	60.00	+	59	49	91.53	89.80	-
12	1	0	100.00	------		60	60	100.00	100.00	+
13	16	17	56.25	70.59	+	45	43	84.44	97.67	+
14	7	13	100.00	69.23	-	54	47	94.44	93.62	-
15	4	3	50.00	66.67	+	57	57	91.23	85.96	-
16	26	30	46.15	60.00	+	35	29	80.00	89.66	+
17	0	2	------	100.00		61	58	96.72	100.00	+
18	23	28	56.52	71.43	+	38	32	92.11	100.00	+
19	21	17	80.95	52.94	-	40	44	87.50	83.72	-
20	2	2	100.00	100.00	+	59	58	98.31	94.83	-
21	2	0	100.00	------	+	58	60	98.28	100.00	+
n					15					21
r					10					9
$P(x \geq r) = E(n, r, p)$					0.15088					0.80834

TABLE XXXII

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE A, $T_3 - T_1$

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_3	T_1 (N = 61)	T_3 (N = 65)	Sign of Diff	T_1	T_3	T_1 (N = 61)	T_3 (N = 65)	Sign of Diff
1	0	1	-----	100.00		61	64	100.00	100.00	+
2	7	5	85.71	60.00	-	54	60	94.44	91.67	-
3	1	0	100.00	------		60	65	100.00	100.00	+
4	7	8	71.43	87.50	+	54	57	96.30	100.00	+
5	1	4	100.00	100.00	+	60	61	100.00	100.00	+
6	7	4	85.71	75.00	-	54	61	100.00	96.72	-
7	2	7	100.00	71.43	-	59	58	86.44	94.83	+
8	4	9	25.00	88.89	+	57	56	98.25	98.21	-
9	13	22	53.85	72.73	+	48	42	85.42	85.71	+
10	4	1	75.00	100.00	+	57	64	100.00	96.88	-
11	2	7	50.00	57.14	+	59	58	91.53	87.93	-
12	1	0	100.00	------		60	65	100.00	98.46	-
13	16	29	56.25	65.52	+	45	36	84.44	91.67	+
14	7	8	100.00	50.00	-	54	57	94.44	85.96	-
15	4	6	50.00	50.00	+	57	59	91.23	79.66	-
16	26	37	46.15	56.76	+	35	26	80.00	92.31	+
17	0	1	------	100.00		61	64	96.72	100.00	+
18	23	19	56.52	63.16	+	38	46	92.11	93.48	+
19	21	27	80.95	62.96	-	40	38	87.50	63.16	-
20	2	3	100.00	100.00	+	59	62	98.31	93.55	-
21	2	2	100.00	100.00	+	58	62	98.28	98.39	+
n					17					21
r					12					11
$P(x \geq r) = E(n, r, p)$					0.07173					0.50000

TABLE XXXIII

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE A, $T_4 - T_1$

			Wrong to Right					Right to Right		
	Wrong First Test					Right First Test				
Item	T_1	T_4	T_1 (N = 61)	T_4 (N = 65)	Sign of Diff	T_1	T_4	T_1 (N = 61)	T_4 (N = 65)	Sign of Diff
1	0	0	0.00	------		61	65	100.00	100.00	+
2	7	9	85.71	77.78	-	54	56	94.44	87.50	-
3	1	1	100.00	100.00	+	60	64	100.00	98.44	-
4	7	6	71.43	83.33	+	54	59	96.30	94.92	-
5	1	5	100.00	100.00	+	60	60	100.00	95.00	-
6	7	2	85.71	100.00	+	54	63	100.00	92.06	-
7	2	7	100.00	85.71	-	59	58	86.44	91.38	+
8	4	7	25.00	57.14	+	57	58	98.25	94.83	-
9	13	16	53.85	68.75	+	48	49	85.42	77.55	-
10	4	1	75.00	100.00	+	57	64	100.00	95.31	-
11	2	9	50.00	66.67	+	59	56	91.53	89.29	-
12	1	1	100.00	100.00	+	60	64	100.00	95.31	-
13	16	20	56.25	65.00	+	45	45	84.44	80.00	-
14	7	15	100.00	86.67	-	54	49	94.44	87.76	-
15	4	9	50.00	55.56	+	57	56	91.23	71.43	-
16	26	40	46.15	52.50	+	35	21	80.00	80.95	+
17	0	1	------	0.00		61	63	96.72	95.24	-
18	23	26	56.52	65.38	+	38	39	92.11	64.10	-
19	21	27	80.95	55.56	-	40	38	87.50	71.05	-
20	2	2	100.00	100.00	+	59	62	98.31	100.00	+
21	2	0	100.00	------		58	64	98.28	98.44	+
n					18					21
r					14					5
P(x ≧ r) = E(n, r, p)					0.01544					0.99640

TABLE XXXIV

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE B, $T_2 - T_1$

Item	Wrong First Test T_1	Wrong First Test T_2	Wrong to Right T_1 (N = 56)	Wrong to Right T_2 (N = 60)	Wrong to Right Sign of Diff	Right First Test T_1	Right First Test T_2	Right to Right T_1 (N = 56)	Right to Right T_2 (N = 60)	Right to Right Sign of Diff
1	32	41	56.25	68.29	+	23	19	47.83	84.21	+
2	4	11	75.00	90.91	+	52	49	78.85	91.84	+
3	10	6	60.00	66.67	+	46	54	71.74	74.07	+
4	20	17	30.00	47.06	+	36	43	36.11	72.09	+
5	18	17	27.78	23.53	-	38	42	31.58	47.62	+
6	30	28	46.67	60.71	+	26	32	57.69	81.25	+
7	33	35	27.27	48.57	+	23	25	52.17	48.00	-
8	25	25	40.00	48.00	+	31	35	41.94	68.57	+
9	13	10	84.62	60.00	-	43	50	88.37	92.00	+
10	12	23	25.00	43.48	+	44	37	59.09	62.16	+
11	8	14	37.50	85.71	+	48	46	66.67	82.61	+
12	13	14	53.85	71.43	+	43	46	62.79	82.61	+
13	20	24	60.00	75.00	+	35	36	51.43	69.44	+
14	40	43	50.00	55.81	+	16	17	37.50	64.71	+
15	32	24	43.75	66.67	+	24	36	50.00	61.11	+
16	15	19	86.67	78.95	-	41	41	78.05	87.80	+
17	21	20	57.14	80.00	+	35	40	74.29	77.50	+
18	24	30	33.33	70.00	+	32	30	50.00	63.33	+
19	4	1	0.00	0.00	+	52	59	57.69	72.88	+
20	7	8	57.14	75.00	+	49	52	67.35	75.00	+
21	29	38	44.83	47.37	+	27	22	40.74	63.64	+
22	7	9	57.14	44.44	-	49	51	73.47	90.20	+
23	0	3	-----	66.67		56	57	64.29	84.21	+
24	1	0	0.00	-----		55	60	72.73	86.67	+
25	21	28	47.62	67.86	+	35	31	80.00	93.55	+
26	1	0	0.00	-----		55	59	69.09	84.75	+
27	16	13	75.00	69.23	-	40	46	87.50	69.57	-
28	13	15	38.46	20.00	-	43	44	58.14	72.73	+
n					25					28
r					19					26
$P(x \geq r) = E(n, r, p)$					0.00732					0.00000

TABLE XXXV

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE B, T_3 - T_1

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_3	T_1 (N = 56)	T_3 (N = 57)	Sign of Diff	T_1	T_3	T_1 (N = 56)	T_3 (N = 57)	Sign of Diff
1	32	51	56.25	58.82	+	23	6	47.83	83.33	+
2	4	10	75.00	90.00	+	52	47	78.85	78.72	-
3	10	3	60.00	0.00	-	46	54	71.74	92.59	+
4	20	22	30.00	31.82	+	36	35	36.11	57.14	+
5	18	18	27.78	27.78	+	38	37	31.58	37.84	+
6	30	38	46.67	63.16	+	26	19	57.69	78.95	+
7	33	39	27.27	48.72	+	23	18	52.17	44.44	-
8	25	21	40.00	52.38	+	31	36	41.94	61.11	+
9	13	12	84.62	66.67	-	43	45	88.37	86.67	-
10	12	29	25.00	48.28	+	44	28	59.09	42.86	-
11	8	14	37.50	78.57	+	48	43	66.67	81.40	+
12	13	16	53.85	37.50	-	43	40	62.79	72.50	+
13	20	25	60.00	44.00	-	35	32	51.43	62.50	+
14	40	44	50.00	59.09	+	16	11	37.50	63.64	+
15	32	27	43.75	59.26	+	24	30	50.00	73.33	+
16	15	11	86.67	81.82	-	41	46	78.05	82.61	+
17	21	11	57.14	63.64	+	35	46	74.29	84.78	+
18	24	24	33.33	37.50	+	32	33	50.00	57.58	+
19	4	6	0.00	50.00	+	52	50	57.69	68.00	+
20	7	10	57.14	40.00	-	49	47	67.35	70.21	+
21	29	35	44.83	48.57	+	27	21	40.74	61.90	+
22	7	11	57.14	81.82	+	49	46	73.47	67.39	-
23	0	3	-----	33.33		56	54	64.29	72.22	+
24	1	0	0.00	------		55	57	72.73	77.19	+
25	21	21	47.62	80.95	+	35	36	80.00	72.22	-
26	1	1	0.00	100.00	+	55	56	69.09	67.86	-
27	16	13	75.00	76.92	+	40	44	87.50	84.09	-
28	13	11	38.46	36.36	-	43	46	58,14	60.87	+
n					26					28
r					19					20
$P(x \geq r) = E(n, r, p)$.					0.01448					0.01785

TABLE XXXVI

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE B, T_4 - T_1

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_4	T_1 (N = 56)	T_4 (N = 65)	Sign of Diff	T_1	T_4	T_1 (N = 56)	T_4 (N = 65)	Sign of Diff
1	32	44	56.25	59.09	+	23	20	47.83	90.00	+
2	4	12	75.00	83.33	+	52	52	78.85	96.15	+
3	10	12	60.00	66.67	+	46	52	71.74	76.92	+
4	20	39	30.00	30.77	+	36	26	36.11	57.69	+
5	18	32	27.78	18.75	-	38	31	31.58	32.26	+
6	30	44	46.67	63.64	+	26	20	57.69	80.00	+
7	33	44	27.27	36.36	+	23	21	52.17	42.86	-
8	25	26	40.00	53.85	+	31	39	41.94	43.59	+
9	13	13	84.62	69.23	-	43	51	88.37	92.16	+
10	12	24	25.00	62.50	+	44	40	59.09	65.00	+
11	8	24	37.50	50.00	+	48	41	66.67	65.85	-
12	13	16	53.85	56.25	+	43	48	62.79	72.92	+
13	20	24	60.00	70.83	+	35	40	51.43	57.50	+
14	40	55	50.00	52.73	+	16	10	37.50	70.00	+
15	32	35	43.75	45.71	+	24	30	50.00	63.33	+
16	15	25	86.67	76.00	-	41	40	78.05	87.50	+
17	21	22	57.14	68.18	+	35	43	74.29	67.44	-
18	24	32	33.33	40.62	+	32	33	50.00	33.33	-
19	4	3	0.00	100.00	+	52	62	57.69	64.52	+
20	7	10	57.14	70.00	+	49	55	67.35	65.45	-
21	29	44	44.83	43.18	-	27	21	40.74	52.38	+
22	7	9	57.14	66.67	+	49	56	73.47	71.43	-
23	0	1	-----	0.00		56	64	64.29	71.88	+
24	1	2	0.00	50.00	+	55	63	72.73	74.60	+
25	21	26	47.62	69.23	+	35	39	80.00	74.36	-
26	1	4	0.00	50.00	+	55	61	69.09	67.21	-
27	16	11	75.00	63.64	-	40	54	87.50	85.19	-
28	13	14	38.46	42.86	+	43	51	58.14	70.59	+
n					27					28
r					22					19
$P(x \geq r) = E(n, r, p)$					0.00076					0.04358

TABLE XXXVII

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE C, $T_2 - T_1$

Item	Wrong First Test T_1	Wrong First Test T_2	Wrong to Right T_1 (N = 47)	Wrong to Right T_2 (N = 60)	Sign of Diff	Right First Test T_1	Right First Test T_2	Right to Right T_1 (N = 47)	Right to Right T_2 (N = 60)	Sign of Diff
1	5	5	100.00	40.00	-	42	55	83.33	83.64	+
2	5	9	60.00	44.44	-	42	51	95.24	78.43	-
3	16	27	56.25	74.07	+	31	33	80.65	87.88	+
4	8	9	25.00	44.44	+	39	51	87.18	92.16	+
5	26	33	50.00	39.39	-	21	27	61.90	77.78	+
6	5	8	80.00	50.00	-	42	52	100.00	94.23	-
7	10	14	50.00	50.00	+	37	46	91.89	91.30	-
8	18	31	38.89	54.84	+	29	29	72.41	68.97	-
9	7	4	100.00	25.00	-	40	56	97.50	96.43	-
10	8	5	75.00	80.00	+	39	55	89.74	81.82	-
11	4	1	100.00	100.00	+	43	59	88.37	83.05	-
12	17	18	58.82	88.89	+	30	42	90.00	78.57	-
13	4	6	100.00	83.33	-	43	54	93.02	96.30	+
14	9	17	66.67	76.47	+	38	43	78.95	95.35	+
15	43	53	34.88	50.94	+	4	7	75.00	42.86	-
16	11	11	36.36	54.55	+	36	49	66.67	73.47	+
17	1	2	100.00	100.00	+	46	58	97.83	98.28	-
18	1	3	100.00	100.00	+	46	57	93.48	96.49	+
19	2	4	50.00	100.00	+	45	56	93.33	91.07	-
20	3	7	100.00	57.14	-	44	53	95.45	98.11	+
21	30	32	40.00	43.75	+	17	28	47.06	46.43	-
22	7	4	57.14	50.00	-	40	56	85.00	82.14	-
23	4	0	25.00	------		43	60	90.70	86.67	-
24	32	38	25.00	57.89	+	15	22	53.33	40.91	-
n					23					24
r					15					9
$P(x \geq r) = E(n, r, p)$					0.10502					0.92421

TABLE XXXVIII

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE C, T_2 - T_1

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_3	T_1 (N = 47)	T_3 (N = 47)	Sign of Diff	T_1	T_3	T_1 (N = 47)	T_3 (N = 47)	Sign of Diff
1	5	6	100.00	100.00	+	42	41	83.33	82.93	-
2	5	10	60.00	30.00	-	42	37	95.24	81.08	-
3	16	23	56.25	73.91	+	31	24	80.65	95.83	+
4	8	9	25.00	66.67	+	39	38	87.18	89.47	+
5	26	21	50.00	42.86	-	21	26	61.90	53.85	-
6	5	8	80.00	50.00	-	42	39	100.00	89.74	-
7	10	13	50.00	38.46	-	37	34	91.89	91.18	-
8	18	25	38.89	44.00	+	29	22	72.41	77.27	+
9	7	10	100.00	90.00	-	40	37	97.50	86.49	-
10	8	9	75.00	77.78	+	39	38	89.74	86.84	-
11	4	6	100.00	83.33	-	43	41	88.37	92.68	+
12	17	13	58.82	61.54	+	30	34	90.00	73.53	-
13	4	4	100.00	75.00	-	43	43	93.02	100.00	+
14	9	15	66.67	66.67	+	38	32	78.95	84.38	+
15	43	41	34.88	56.10	+	4	6	75.00	83.33	+
16	11	11	36.36	45.45	+	36	36	66.67	63.89	-
17	1	3	100.00	66.67	-	46	44	97.83	100.00	+
18	1	4	100.00	100.00	+	46	42	93.48	100.00	+
19	2	2	50.00	50.00	+	45	45	93.33	93.33	+
20	3	8	100.00	50.00	-	44	39	95.45	87.18	-
21	30	28	40.00	35.71	-	17	19	47.06	36.84	-
22	7	7	57.14	71.43	+	40	39	87.50	82.05	-
23	4	3	25.00	33.33	+	43	43	90.70	81.40	-
24	32	32	25.00	34.38	+	15	14	53.33	71.43	+
n					24					24
r					14					11
$P(x \geq r) = E(n, r, p)$					0.27063					0.72937

TABLE XXXIX

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE C, $T_4 - T_1$

Item	Wrong First Test T_1	Wrong First Test T_4	Wrong to Right T_1 (N = 47)	Wrong to Right T_4 (N = 41)	Wrong to Right Sign of Diff	Right First Test T_1	Right First Test T_4	Right to Right T_1 (N = 47)	Right to Right T_4 (N = 41)	Right to Right Sign of Diff
1	5	2	100.00	0.00	-	42	39	83.33	69.23	-
2	5	5	60.00	60.00	+	42	36	95.24	66.67	-
3	16	21	56.25	66.67	+	31	20	80.65	85.00	+
4	8	11	25.00	54.55	+	39	30	87.18	86.67	-
5	26	28	50.00	39.29	-	21	13	61.90	30.77	-
6	5	3	80.00	66.67	-	42	38	100.00	97.37	-
7	10	11	50.00	90.91	+	37	30	91.89	86.67	-
8	18	19	38.89	52.63	+	29	22	72.41	81.82	+
9	7	4	100.00	75.00	-	40	37	97.50	81.08	-
10	8	7	75.00	71.43	-	39	34	89.74	79.41	-
11	4	4	100.00	50.00	-	43	37	88.37	70.27	-
12	17	13	58.82	61.54	+	30	28	90.00	82.14	-
13	4	6	100.00	83.33	-	43	35	93.02	100.00	+
14	9	9	66.67	66.67	+	38	32	78.95	81.25	+
15	43	38	34.88	36.84	+	4	3	75.00	0.00	-
16	11	6	36.36	50.00	+	36	35	66.67	77.14	+
17	1	3	100.00	66.67	-	46	38	97.83	100.00	+
18	1	6	100.00	100.00	+	46	35	93.48	100.00	+
19	2	2	50.00	50.00	+	45	39	93.33	79.49	-
20	3	5	100.00	60.00	-	44	36	95.45	100.00	+
21	30	19	40.00	31.58	-	17	22	47.06	40.91	-
22	7	4	57.14	25.00	-	40	37	85.00	83.78	-
23	4	4	25.00	50.00	+	43	37	90.70	81.08	-
24	32	26	25.00	46.15	+	15	15	53.33	53.33	+
n					24					24
r					13					9
$P(x \geq r) = E(n, r, p)$					0.41941					0.92421

TABLE XL

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE D, $T_2 - T_1$

	Wrong First Test		Wrong to Right			Right First Test		Right to Right		
Item	T_1	T_2	T_1 (N = 50)	T_2 (N = 48)	Sign of Diff	T_1	T_2	T_1 (N = 50)	T_2 (N = 48)	Sign of Diff
1	1	2	100.00	100.00	+	49	45	71.43	84.44	+
2	12	11	41.67	72.73	+	38	37	76.32	83.78	+
3	4	3	75.00	66.67	-	46	45	95.65	97.78	+
4	16	13	81.25	76.92	-	34	35	88.24	80.00	-
5	28	24	50.00	62.50	+	22	24	63.64	75.00	+
6	25	18	68.00	72.22	+	25	30	84.00	80.00	-
7	18	19	66.67	63.16	-	32	29	68.75	79.31	+
8	27	31	33.33	61.29	+	23	17	39.13	70.59	+
9	20	31	35.00	48.39	+	30	17	50.00	76.47	+
10	6	8	16.67	50.00	+	44	40	75.00	87.50	+
11	19	11	57.89	45.45	-	31	37	83.87	67.57	-
12	5	10	40.00	70.00	+	45	38	73.33	81.58	+
13	10	15	50.00	66.67	+	40	33	82.50	78.79	-
14	34	33	20.59	21.21	+	16	15	25.00	13.33	-
15	32	36	31.25	16.67	-	18	12	27.78	25.00	-
16	18	25	50.00	68.00	+	32	23	43.75	73.91	+
17	9	14	66.67	92.86	+	41	34	80.49	82.35	+
18	25	27	48.00	48.15	+	25	21	76.00	71.43	-
19	13	20	69.23	70.00	+	37	28	59.46	64.29	+
20	33	35	39.39	62.86	+	17	13	35.29	38.46	+
21	31	28	22.58	17.86	-	19	20	31.58	30.00	-
22	20	20	35.00	70.00	+	30	28	76.67	75.00	-
23	24	18	45.83	77.78	+	26	29	73.08	72.41	-
n					23					23
r					17					13
$P(x \geq r) = E(n, r, p)$					0.01734					0.33882

TABLE XLI

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE D, T_3 - T_1

Item	Wrong First Test T_1	Wrong First Test T_3	Wrong to Right T_1 (N = 50)	Wrong to Right T_3 (N = 53)	Wrong to Right Sign of Diff	Right First Test T_1	Right First Test T_3	Right to Right T_1 (N = 50)	Right to Right T_3 (N = 53)	Right to Right Sign of Diff
1	1	2	100.00	100.00	+	49	51	71.43	82.35	+
2	12	12	41.67	75.00	+	38	41	76.32	75.61	-
3	4	4	75.00	75.00	+	46	49	95.65	87.76	-
4	16	15	81.25	53.33	-	34	38	88.24	86.84	-
5	28	28	50.00	46.43	-	22	25	63.64	80.00	+
6	25	17	68.00	76.47	+	25	36	84.00	80.56	-
7	18	26	66.67	53.85	-	32	27	68.75	77.78	+
8	27	27	33.33	59.26	+	23	26	39.13	61.54	+
9	20	37	35.00	54.05	+	30	16	50.00	56.25	+
10	6	14	16.67	78.57	+	44	39	75.00	92.31	+
11	19	17	57.89	70.59	+	31	36	83.87	75.00	-
12	5	11	40.00	63.64	+	45	42	73.33	80.95	+
13	10	21	50.00	57.14	+	40	32	82.50	87.50	+
14	34	47	20.59	27.66	+	16	6	25.00	16.67	-
15	32	43	31.25	48.84	+	18	9	27.78	22.22	-
16	18	25	50.00	80.00	+	32	28	43.75	82.14	+
17	9	19	66.67	84.21	+	41	34	80.49	91.18	+
18	25	33	48.00	63.64	+	25	20	76.00	85.00	+
19	13	32	69.23	71.88	+	37	21	59.46	85.71	+
20	33	25	39.39	64.00	+	17	28	35.29	67.86	+
21	31	37	22.58	16.22	-	19	16	31.58	56.25	+
22	20	25	35.00	56.00	+	30	28	76.67	75.00	-
23	24	16	45.83	75.00	+	26	37	73.08	81.08	+
n					23					23
r					19					15
$P(x \geq r) = E(n, r, p)$					0.00130					0.10502

TABLE XLII

PER CENT CHANGE IN RESPONSES FROM FIRST TEST TO RETEST BY ITEM, ARTICLE D, T_4 - T_1

Item	Wrong First Test T_1	Wrong First Test T_4	Wrong to Right T_1 (N = 50)	Wrong to Right T_4 (N = 50)	Wrong to Right Sign of Diff	Right First Test T_1	Right First Test T_4	Right to Right T_1 (N = 50)	Right to Right T_4 (N = 50)	Right to Right Sign of Diff
1	1	1	100.00	100.00	+	49	48	71.43	81.25	+
2	12	10	41.67	70.00	+	38	40	76.32	82.50	+
3	4	2	75.00	100.00	+	46	48	95.65	100.00	+
4	16	14	81.25	50.00	-	34	36	88.24	80.56	-
5	28	23	50.00	52.17	+	22	27	63.64	96.30	+
6	25	20	68.00	85.00	+	25	30	84.00	90.00	+
7	18	19	66.67	78.95	+	32	31	68.75	67.74	-
8	27	30	33.33	46.67	+	23	20	39.13	65.00	+
9	20	27	35.00	33.33	-	30	23	50.00	60.87	+
10	6	9	16.67	66.67	+	44	41	75.00	82.93	+
11	19	14	57.89	57.14	-	31	35	83.87	82.86	-
12	5	9	40.00	33.33	-	45	40	73.33	70.00	-
13	10	20	50.00	80.00	+	40	30	82.50	90.00	+
14	34	39	20.59	23.08	+	16	11	25.00	27.27	+
15	32	35	31.25	31.43	+	18	15	27.78	33.33	+
16	18	23	50.00	60.87	+	32	27	43.75	81.48	+
17	9	17	66.67	82.35	+	41	33	80.49	78.79	-
18	25	28	48.00	64.29	+	25	21	76.00	61.90	-
19	13	29	69.23	58.62	-	37	20	59.46	85.00	+
20	33	28	39.39	46.43	+	17	21	35.29	66.67	+
21	31	35	22.58	31.43	+	19	13	31.58	46.15	+
22	20	24	35.00	75.00	+	30	25	76.67	64.00	-
23	24	27	45.83	70.37	+	26	22	73.08	90.91	+
n					23					23
r					18					16
$P(x \geq r) = E(n, r, p)$					0.00531					0.04657

TABLE XLIII

SUMMARY OF RESULTS OF SIGN TESTS BY ARTICLE FOR COMPARISONS OF TREATMENT ONE WITH TREATMENTS TWO, THREE, AND FOUR

	Treatment	Wrong to Right			Right to Right		
Article	Comparisons	n	r	p	n	r	p
A	$T_2 - T_1$	15	10	0.15088	21	9	0.80834
A	$T_3 - T_1$	17	12	0.07173	21	11	0.50000
A	$T_4 - T_1$	18	14	0.01544	21	5	0.99640**
B	$T_2 - T_1$	25	19	0.00732*	28	26	0.00000*
B	$T_3 - T_1$	26	19	0.01448*	28	20	0.01785*
B	$T_4 - T_1$	27	22	0.00076**	28	19	0.04358
C	$T_2 - T_1$	23	15	0.10502	24	8	0.96804
C	$T_3 - T_1$	24	14	0.27063	24	11	0.72937
C	$T_4 - T_1$	24	13	0.41941	24	9	0.92421
D	$T_2 - T_1$	23	17	0.01734*	23	13	0.33882
D	$T_3 - T_1$	23	19	0.00130**	23	15	0.10502
D	$T_4 - T_1$	23	18	0.00531*	23	16	0.04657

*Significant, five per cent level
**Significant, one per cent level

the percentages of wrong responses on the first test which changed to right on the retest (W-R) is considered, T_2 is significantly favored over T_1 for Articles B (0.05 level), and D (0.05 level), and T_2 is favored over T_1 for Articles A and C, although not significantly. Treatment three is favored significantly over T_1 for Articles B (0.05 level) and D (0.01 level), and T_3 is favored over T_1 for Articles A and C, although not significantly. Treatment four is favored significantly over T_1 for Articles A (0.05 level), B (0.01 level), and D (0.05 level), and T_4 is favored over T_1 for Article C, although not significantly. In no instance is T favored.

When the percentage of right responses on the first test which remained right on the retest (R-R) is considered, T_2 is significantly favored over T_1 for Article B (0.01 level) and T_3 is significantly favored over T_1 for Article B (0.05 level). Treatment one is significantly favored over T_4 for Article A (0.01 level). For the other treatment pairs, there is no consistent pattern.

Summary and Conclusions

In the course "Human Growth and Learning", eight sections of college students each semester during the academic year 1964-65 read four journal articles and took a test and retest over the articles. Four feedback treatments were investigated: immediate feedback, one hour delay of feedback, two day delay, and one week delay.

Two kinds of measurements were used for testing the hypothesis of no difference between the groups receiving immediate feedback and groups in which feedback was delayed: first, scores for each individual and second, percentages for each item.

The scores for individuals were subjected to an analysis of covariance using the regression method in order to test the hypothesis of no difference between groups receiving the different feedback treatments. Variables considered in covariance were age, grade point average, Otis Gamma, number of hours taken in psychology, number of hours taken in behavioral sciences other than psychology, sex, college classification, major area of study and the first test scores on the four articles. One hour delay had the largest positive effect for three of the four articles. Two day delay of feedback had the largest positive effect for one of the four articles and was second largest for two of the four articles. Immediate feedback had the least positive or sometimes a negative effect.

The hypothesis of no difference between paired treatment effects was tested for each of the feedback treatments. One hour delay and two day delay of feedback was consistently superior to immediate feedback and one week delay of feedback.

The sign test was used to test the hypothesis of no difference between groups where the percentages for items were considered. One hour, two day, and one week delays of feedback were consistently favored over immediate feedback when considering the percentage of wrong responses on the first test which changed to right on the retest.

It may be said that under the conditions of this study using meaningful material with human subjects:

1. Immediate feedback has the least positive effect of any of the feedback treatments.
2. One hour, and two day delays of feedback are more effective than immediate feedback or one week delay.

Chapter VI

Conclusions and Implications

The previous study by Pressey and Kinzer (4) raised several issues among which are:

1. Whether the adjunct auto-instructional techniques can be successfully utilized below the college level and with subject matter other than educational psychology.

2. Whether classroom teachers with encouragement can adequately develop adjunct auto-instructional material.

3. Whether immediate knowledge of results is an essential element in meaningful learning with human subjects.

In the course Computer Techniques, at the college level, all significant differences were on mid-term examinations and favored the experimental group, but there were no significant differences between groups for the final examination, final program grade, or number of programs in late. The courses at the secondary school level, first year algebra, and junior high school general science, did not show significant differences. The earlier work in Human Growth and Learning (Educational Psychology) did show significant differences on chapter topics but not on mid-term and final examinations. Hence, one might infer that adjunct auto-instruction requires study skills more often possessed by college level students than by secondary school students. There is insufficient evidence on this latter point, and an additional investigation is warranted. The effectiveness of adjunct auto-instruction does not appear to be related to the clarity and preciseness of the subject matter.

Instructors found the production of adjunct auto-instructional exercises laborious and time consuming, so much so that the teacher construction of such exercises does not appear to be practicable for teachers with a full load of teaching. The opinions of the teachers were not canvassed systematically but those who worked on the production of adjunct auto-instructional materials expressed the opinion that although the writing of the learning exercises was laborious the skill improved with practice. The teachers on this project were compensated by being relieved of some of their teaching load, and this was a factor in their enthusiasm. They believed that expertness in the preparation of adjunct auto-instructional materials was well worth cultivating since it contributed to their own increased effectiveness as teachers.

The finding of greatest importance is probably the discovery that immediate knowledge of results is not necessary. The notion that immediate feedback is better than delayed feedback has been found in previous studies to hold for most learning, but the present investigators tend to agree with Hilgard, "There are probably a number of different kinds of learning . . . . It is quite probable that these different kinds of learning follow different laws . . . ." (2)

This study indicates the superiority of certain delays of feedback. An implication of this finding is that papers should be returned to students within a time range in which the students still show interest in the material. The finding of superior learning from certain feedback delays should be thoroughly investigated because such a finding, if it has generality, would have great impact upon the understanding of meaningful human learning and the production of learning materials with various feedback devices.

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Appendix A

Sample Exercises in Computer Techniques

AUTO-INSTRUCTIONAL EXERCISE
COMPUTER TECHNIQUES ENG. 70
GENERAL REVIEW

1. A program written in FORTRAN

   (a) can be performed directly by the computer to process data and to provide output results.
   (b) must be transformed into a corresponding machine language program before the computer can process data and provide output results.
   (c) is no easier to work out and to debug than the corresponding machine language program.

2. When a FORTRAN program is compared with the corresponding machine language program, we almost always observe that

   (a) the machine language program consists of a larger number of simpler statements than the FORTRAN program.
   (b) the number of statements in the FORTRAN program and in the machine language program are always equal in number.
   (c) it would require no more detailed planning to write a machine language program as compared with writing the corresponding FORTRAN program.

3. As far as the monitor and the compiler are concerned

   (a) they are the same. There is no difference between these two programs.
   (b) the compiler's function is to convert programs written in FORTRAN or other programming language into corresponding programs in machine language. The monitor, on the other hand, performs for the computer operator many of the routine tasks in compiling and running programs and thus saves much computer time.
   (c) the layout of cards for the monitor is the same as for FORTRAN program cards.

4. With respect to floating point and fixed point numbers, conversion may be accomplished

(a) *either* (i) by statements of the type

```
NUTS = DØG  or
CAT = MARY or
KAT(4,7) = CAT(3,6)  or
CAT(JACK, IKE) = KAT(IKE, JØE)
```

or (ii) by using the functions

FLØTF (for conversion of fixed point to floating point)
XFIXF (for conversion of floating point to fixed point)

(b) only by statements as exemplified by (a)(i) above.
(c) only by functions as cited in (a)(ii) above.

5. The diagnostic MIXED ARITHMETIC MODE is printed out when, with certain exceptions, the expression which is to the right of the equal sign in an arithmetic statement instructs the computer to process both fixed point and floating point numbers.

(a) One exception may be that a floating point numerical value may be raised to a fixed point power.
(b) Permitted exceptions include those mentioned in (a) and also in (c).
(c) One exception may be the use of fixed point numbers or fixed point variable names to specify matrix positions as in the examples XYZ(12, 8), XYZ(JØE, JACK), XYZ(12, IKE).

6. Numbers, as such, namely 129, 148.23, 6.06E23, may be included in arithmetic FORTRAN statements

(a) on either side of the equal sign.
(b) *only* to the right of the equal sign *and only* in combination with one or more variable names, with due regard for the rules regarding mixed arithmetic mode.
(c) only to the right of the equal sign *either* in combination with variable names *or* not in combination with variable names, but provided, of course, that the rules regarding mixed arithmetic mode are obeyed.

7. If we write E4 or E-13 or similar combinations of E with a number in the range + 49 to - 50

(a) this will be interpreted by the computer as meaning 1×10^4 for E4 and 1×10^{-13} for E-13 both when reading input data and also when E4 or E-13 or the like is found to the right of the equal sign in an arithmetic statement.

(b) the interpretation as stated under (a) above will occur only when E4 or E-13 or the like is found to the right of the equal sign in an arithmetic statement.

(c) in order to write a floating point number we must write at least one digit and a decimal point preceding E4 or E-13 or the like as otherwise no floating point number is specified.

8. A FØRMAT statement to be used with a READ or PRINT statement

(a) may be entered anywhere within the main program or anywhere within a program segment within which the READ or PRINT is to be performed.

(b) may be entered in any position before the READ or PRINT statement that cites the FØRMAT in question. This rule applies both to the main program and to any program segment.

(c) must be entered immediately preceding the READ or PRINT statement that cites the FØRMAT in question.

9. A DIMENSIØN statement to define a matrix

(a) may be entered anywhere within the main program or anywhere within a program segment in which the matrix is used.

(b) may be entered in any position before a statement which mentions the matrix in question. This rule applies both to the main program and to any program segment.

(c) must be entered immediately preceding the first statement which mentions the matrix in question. This rule applies both to the main program and to any program segment.

10. Assume we have a FØRMAT statement which specifies one or more fields, such as I3, F5.2, E10.5, 3I3, 6F5.2, 2E10.5. Then in reading a punched card

    (a) the FØRMAT statement is applied *completely once and only once* in reading each punched card. All specified columns, punched or otherwise are read. For a completely unpunched field, the value zero is assumed.

    (b) if card columns are punched over and above the total number of card columns specified by the fields in the FØRMAT statement, then such additional columns are read by automatically reapplying as much of the FØRMAT as may be needed to read such additional columns. Furthermore, if, for some of the specified fields in the FØRMAT statement, corresponding columns are not punched, then the columns which correspond to these fields are simply ignored.

    (c) if card columns are punched over and above those specified by the FØRMAT or if card columns corresponding to one or more field specifications are unpunched, this will cause the computer to detect an error and program performance will be terminated.

11. Assume a FØRMAT as specified in 10 above. Then

    (a) a corresponding READ statement may list the variables to which numerical values are to be assigned in *any* *order* as assignment of numerical values is determined by first alphabetizing the variable names and second assigning the data value in field 1 to the 1st variable name in the alphabetical list, the data value in field 2 to the 2nd variable in the alphabetical list, etc.

    (b) the variable names in the READ statement must correspond to the sequence of data items punched in the card and the punching of each successive data item must be in accord with the successive fields in the FØRMAT statement.

    (c) there is no fixed relationship between the order of punching data items in a card to be read and the sequential order of listing variable names in a READ statement. Nor does such a relationship need to be defined, as the way in which variable names are used in arithmetic statements indicates how numerical data values are to be assigned to variable names.

12. When a field specification in a FØRMAT statement is applied to read a data card,

(a) the punching of the columns within the field is interpreted in accord with the field specification. Accordingly, the same punching may be differently interpreted by different field specifications. In other words, the same punching may be interpreted as different numerical values by different field specifications.
(b) the punching of any one sequence of columns in a data card will always be interpreted as the same numerical value regardless of the field specification or of the variable name that will be assigned.
(c) the variable name in the READ statement determines exclusively how the punching in a sequence of columns in a data card will be interpreted as a numerical value.

13. Executable statements in FORTRAN

(a) are only arithmetic statements.
(b) are only arithmetic statements and transfer statements.
(c) include arithmetic statements, READ, PRINT, transfer statements, DØ statements, CØNTINUE and CALL statements.

14. Non-executable statements in FORTRAN

(a) are comments and no others.
(b) are comments, FØRMAT and DIMENSIØN statements and no others.
(c) include comments, FØRMAT, DIMENSIØN statements and also the headings, i.e., the first line, in defining a SUBRØUTINE or a FUNCTIØN subprogram or an arithmetic function.

15. Normally, the printing of each line of output is followed by a carriage return and automatic advancement of the paper to the next line or from the last line on a sheet to the first line of the next sheet. With respect to other movement of the paper by a PRINT instruction and the printing of output results, paper movement is controlled

(a) *exclusively* by the character in the first position in the line of output.
(b) *either* by the character in the first position in the line of output or by / (i.e., the slash mark).
(c) *exclusively* by / (i.e., the slash mark).

16. In order to insure, during output printing, no more than the line-by-line automatic advance of the paper after printing a line, it is essential that *no* character shall occur in the first position of a line of output. This can be assured

(a) *only* by citing a Hollerith field in which the first space is specified as being blank, as may be done, for example by 1H Δ , or 5H Δ AREA, where Δ indicates a blank.
(b) *only* by a field specification which makes it impossible that a character should occur in the first position in the line of output. Examples of such field specifications are I12 and E20.8.
(c) either by (a) *or* (b).

17. Our computer has 10 digits available for processing and storing fixed point numbers. Assume, during the course of a computation, that the computer is instructed to compute a number larger than 9999999999 which may be written with either a positive or a negative algebraic sign. The consequence will be

(a) 1st, the last ten digits in the computed number will be retained and all other digits will be lost. 2nd, the computations specified by the program will continue. 3rd, at the conclusion of the program, the printed output will indicate occurrence of an overflow.
(b) 1st, the first ten digits of the computed number will be retained and all other digits will be lost. 2nd, the computations specified by the program will continue. 3rd, at the conclusion of the program, the printed output will indicate occurrence of an overflow.

(c) neither (a) nor (b) will occur but the program will be terminated.

18. Our computer uses its 10 digit memory units for processing and storing floating point numbers so that the first two digits record the sum of the power of ten plus 50 while the last eight digits record eight digits of the floating point number. For example, 41.278907×10^{22} is recorded as 7441278907 and $0.026745912 \times 10^{-14}$ is recorded as 3526745912. Assume, during the course of a computation, that the computer is instructed to compute a number which, when written in the form $0.m \times 10^{n}$, is characterized as follows:

(i) $-50 \leqslant n \leqslant 49$
(ii) m is a string of more than eight digits.

Then, in such a case

(a) 1st, the last eight digits in m will be retained and all other digits will be lost. 2nd, the computations specified by the program will continue. 3rd, at the conclusion of the program, the printed output will indicate occurrence of an overflow.
(b) 1st, the first eight digits of the computed number will be retained and all other digits will be lost by our FØRTRAN system. 2nd, the computations specified by the program will continue. 3rd, at the conclusion of the program, the printed output will NOT indicate an overflow.
(c) neither (a) nor (b) will occur but the program will be terminated.

19. Assume, during the course of a computation, that the computer is instructed to compute a number which, when written in the form $0.m \times 10^{n}$ is characterized as follows:

(i) $49 < n < -50$
(ii) m is a string of more than eight digits.

Then in such a case

(a) 1st, if $(n + 50) > 100$, the last two digits of the sum are retained and other digits are lost or if $(n + 50) < 0$ then the last two digits of the tens complement, e.g., $100 - (n + 50)$ when $-100 < (n + 50) < 0$, is recorded as the first two digits of the number. 2nd, the first eight digits of m are retained and other digits in m are dropped by our FORTRAN system. 3rd, the computations specified by the program will continue and 4th, the printed output will indicate occurrence of either an overflow, if $(n + 50) > 100$ or of an underflow, if $(n + 50) < 0$.

(b) 1st, if $(n + 50) > 100$, the first two digits of the sum are retained and other digits are lost or if $(n + 50) < 0$ then the algebraic sign of $(n + 50)$ is made positive and the first two digits of the resulting number are retained. 2nd, the first eight digits of m are retained and other digits in m are dropped by our FORTRAN system. 3rd, the computations specified by the program will continue and 4th, the printed output will indicate occurrence of either an overflow, if $(n + 50) > 100$ or of an underflow, if $(n + 50) < 0$.

(c) neither (a) nor (b) will occur but the program will be terminated.

20. Assume that we have the following situation: (i) a number is correctly punched in a field in E notation, e.g., 4075E13 (ii) the FØRMAT specifies the field of the number as E8.0 (iii) the corresponding READ statement specifies for the number a fixed point variable name, e.g., JØKER. In such a case

(a) the diagnostic "MIXED ARITHMETIC MODE" will be provided.

(b) the number will be automatically converted to a fixed point number and its numerical value assigned to JØKER.

(c) the card punching will first be interpreted in accord with the field specification, e.g., E8.0, to the form for machine internal representation, e.g., 6740750000 in our example, and this number then becomes the fixed point numerical value of the fixed point variable, namely JØKER in our example. Thus JØKER has the value 6,740,750,000.

21. Assume the same situation as in 20 but with the change that the number is read into a matrix with a fixed point name, e.g., NUTS. In such a case

(a) same as 20 (a)
(b) same as 20 (c) but the number in machine representation for a floating point number is stored as a fixed point number in the matrix NUTS.
(c) same as 20 (b)

22. Assume that we have the following situation, (i) a number e.g., 483 is punched correctly in an I field such as I5 and (ii) the FØRMAT applied to read it specifies a fixed point field, e.g., I5 but (iii) the READ statement specifies a floating point variable name e.g., SØRRY for the number. In such a case

(a) the card punching will first be interpreted in accord with the field specification, e.g., I5 to the form for machine internal representation, e.g., 0000000483, and this number will then be interpreted as the floating point representation of a floating point variable, e.g., SØRRY.
(b) the diagnostic "MIXED ARITHMETIC MODE" will be provided.
(c) the number will be automatically converted to a fixed point number and its numerical value assigned to SØRRY.

23. Assume the same situation as in 22 but with the change that the number is read into a matrix with a floating point name, e.g., WRECK. In such a case

(a) the diagnostic "MIXED ARITHMETIC MODE" will be provided.
(b) the number will be automatically converted to a fixed point number and its numerical value assigned to WRECK.
(c) the number will be converted as in 22 (a) but the number in machine representation for a fixed point number is stored as a floating point representation of a floating point data item in the matrix, e.g., WRECK.

24. The correct format for the computed GØ TØ instruction is

(a) GØ TØ(n_1, n_2, ..., n_m), INDEX

(b) GØ TØ (n_1, n_2, ..., n_m) INDEX

(c) GØ TØ(n_1, n_2, ..., n_m)

25. In a computed GØ TØ,

(a) the values of n_1, n_2, ..., n_m are fixed point variable names whose values may be computed separately and the largest numerical value is selected to designate the statement that is to be performed next.
(b) statement numbers only are designated by n_1, n_2, ..., n_m and the statement to be performed next is denoted by INDEX, e.g., if INDEX is equal to 5 then the 5th statement number (i.e., n_5 in the list n_1, n_2, ..., n_m), will be performed next.
(c) the values of n_1, n_2, ..., n_m may be either statement numbers or fixed point variable names and otherwise (b) is correct.

26. The control index in a computed GØ TØ statement

(a) may be denoted by a fixed point variable name whose value may be negative but it may not be the name of a matrix.
(b) may be any fixed point variable name including the name of a fixed point matrix with appropriate designation of some matrix position, e.g., KAT(5, 3) or KØW(JØE, NAN).
(c) may be any fixed point variable name - but not the name of a fixed point matrix - provided the numerical value of the fixed point variable is within the range 1 to m where m is specified by n_1, n_2, ..., n_m.

27. A computed GØ TØ

(a) is to be regarded as a convenient way of specifying a multiple branch and controlling its performance.
(b) could not be replaced by a series of IF statements. In other words, a computed GØ TØ must be used to establish a multiple branch.

(c) is used as frequently in simple programs as in complex ones.

28. The control index in a DØ loop

(a) cannot be used as data in statements within the loop.
(b) may be used as a data item provided its numerical value is not altered within the DØ loop.
(c) may be used as a data item and its numerical value may also be altered within the DØ loop.

29. When setting up a DØ loop, it is possible to specify

(a) entering the loop at any point, that is to say, transferring from outside the loop to any statement in the loop.
(b) leaving the loop at any point but only provided it is reentered at some later point.
(c) leaving the loop at any point in the loop but not entering it from outside the loop.

30. The first statement in a DØ loop may be

(a) any statement whatsoever.
(b) only some arithmetic statement.
(c) any executable statement.

31. In our FORTRAN system, the control index of a DØ loop,

(a) may not be allowed to become larger than 999, as four digit numbers are not available for this index.
(b) may become equal to any fixed point number.
(c) may become equal to any positive fixed point number within the number range of the computer.

32. The CØNTINUE statement

- (a) may be used only with a DØ loop.
- (b) may be used anywhere as a dummy statement which is particularly useful wherever the rules require an executable statement of the no-op type.
- (c) insures that the presence of an overflow or underflow will not interrupt performance of the program.

33. Matrices may be used to store

- (a) input data only.
- (b) input data, intermediate results or output results.
- (c) input data or output results only.

34. The specification of matrix position, e.g., KAT(3,6) or CAT(K,N), may be used

- (a) as though it were a variable name but only to the right of the equal sign in an arithmetic statement.
- (b) anywhere that a variable name may be used including, for example, to specify the index of a DØ loop or of a computed GØ TØ.
- (c) as though it were a variable name anywhere in an arithmetic statement but not for specifying the index of a DØ loop or a computed GØ TØ.

35. In flowcharting program segments

- (a) it is advisable to flowchart each of them separately and only once and then, in the main program, to indicate how each program segment is to be used.
- (b) it is necessary that the flowchart for each program segment be included in full each time the program segment is used in the main program.
- (c) it is advisable that the flowchart for each program segment be included in full in the main program the first time that the program segment is used but not when it is used later on in the main program.

36. If a portion of a program is to be repeated some definable number of times at some one stage in a program, it is adviseable to define this portion of the program

(a) either as a loop or a program segment - it doesn't matter which.
(b) as a program segment.
(c) as a loop controlled either by a DØ statement or its equivalent involving an IF statement.

37. If a portion of a program is to be performed at a number of different stages in a lengthy program it is adviseable to define this portion of a program

(a) the same as 36 (a).
(b) the same as 36 (b).
(c) the same as 36 (c).

38. If results computed in a SUBRØUTINE are to be printed out by a PRINT statement in the main program

(a) it is not necessary to insure that the CALL statement is written so that the results in question are assigned to variable names in the main program.
(b) It is necessary to write the CALL statement so that the numerical values are assigned to variable names in the main program but these variable names must be different than in the SUBRØUTINE.
(c) it is necessary to write the CALL statement so that numerical values are assigned to variable names in the main program but these variable names may be the same as in the SURRØUTINE.

39. A CALL statement

(a) must be written so that there is sequential correspondence between the variable names, numerical values or expressions in the CALL statement and the sequence of variables in the SUBRØUTINE heading but no ordering of input and output is required.
(b) must be written as in (a) above, but it is required that all input items be listed first and then all output items.

(c) requires no rules for writing as the program statements suffice to indicate the correspondence.

40. If, in performing a program, an overflow or underflow occurs

(a) nothing need be done about it. The computer will automatically perform any necessary adjustment or compensation.
(b) it is possible to make appropriate adjustments in the program but to do so requires that the overflow or underflow condition shall be anticipated by the programmer.
(c) nothing can be done to adjust such a program which must be abandoned as hopeless.

Appendix B

Sample Exercises in High School Algebra

AUTO-INSTRUCTIONAL EXERCISE No. 17
ALGEBRA 1A

Name____________________________

Seat No______Date_______________

Score_________Period____________

Start_______Stop______Time_____

The objective of this exercise is to familiarize students with the concept of multiplying polynomials.

DIRECTIONS: Read each question CAREFULLY. Choose the answer which you think is the most suitable from those following the question. On the answer card completely erase the black disk in the column under the letter a, b, or c corresponding to the answer which you have chosen. If this is correct the letter "R" will appear when the black has been erased. Continue your choices until you find the correct answer.

1. The distributive principle says that for all values of a, b, and c, $a(b + c)$ is equal to

   (a) $ab + ac$
   (b) $ab + c$
   (c) $a(c + b)$

2. Using the distributive principle, multiply $7(3 + 2)$ and we get

   (a) $7(3) + 2 = 21 + 2 = 23$
   (b) $7(2 + 3) = 7(2) + 3 = 14 + 3 = 17$
   (c) $7(3) + 7(2) = 21 + 14 = 35$

3. Using the distributive principle, multiply $x(2x - 1)$ and we get

   (a) $2x^2 - 1$
   (b) $2x^2 - x$
   (c) $3x - 1$

4. Using the distributive principle, multiply $-2y(-3xy + z)$ and we get

   (a) $6xy^2 - 2yz$

(b) $6xy^2 + z$

(c) $-6xy^2 + 2yz$

5. Multiply: $4ab(5a^2 - 3ab + b^2)$, using the distributive principle. The product is

(a) $20a^3b - 12a^2b^2 + 4ab^3$

(b) $20a^3b - 12a^2b^2 + b^2$

(c) $20a^3b - 3ab + b^2$

6. Multiply: $-2x^2y(-7x^2y - 3x^4)$. The product is

(a) $-14x^4y^2 - 6x^6y$

(b) $-14x^4y - 3x^4$

(c) $14x^4y^2 + 6x^6y$

7. Multiply: $0.2a(a + 0.1b - 0.02c)$. The product is

(a) $0.2a + 0.2b - 0.02c$

(b) $0.2a^2 + 0.1b - 0.02c$

(c) $0.2a^2 + 0.02ab - 0.004ac$

8. To multiply $(20 + 3)$ by $(10 + 2)$ using the distributive principle we would proceed thus

(a) $10(20 + 3) + 2 = 200 + 30 + 2 = 232$
(b) $10(20 + 3) + 2(20 + 3) = 200 + 30 + 40 + 6 = 276$
(c) $10(20 + 3) + 2(20 + 3) = 200 + 3 + 40 + 3 = 246$

9. To multiply $(2t + 3u)$ by $(t + 2u)$ using the distributive prinicple we would proceed thus

(a) $t(2t + 3u) + 2u(2t + 3u) = 2t^2 + 3tu + 4tu + 6u^2 = 2t^2 + 7tu + 6u^2$

(b) $t(2t + 3u) + 2u = 2t^2 + 3tu + 2u$

(c) $t(2t + 3u) + 2u(2t + 3u) = 2t^2 + 3u + 4tu + 3u = 2t^2 + 6u + 4tu$

10. In example no 9 above, let $t = 10$ and $u = 1$ and then $(2t + 3u)(t + 2u) =$

(a) 232
(b) 276
(c) 246

11. Using the distributive principle, multiply $(2t + u)$ by $(2t + 8u)$. The product is

(a) $2t(2t + u) + 8u(2t + u) = 4t^2 + u + 16tu + u = 4t^2 + 16tu + 2u$
(b) $2t(2t + u) + 8u = 4t^2 + 2tu + 8u$
(c) $2t(2t + u) + 8u(2t + u) = 4t^2 + 2tu + 16tu + 8u^2 = 4t^2 + 18tu + 8u^2$

12. In example no 11 above, let $t = 10$ and $u = 1$ and $(2t + u)(2t + 8u)$ equals

(a) 588
(b) 428
(c) 562

In each of the examples 13 through 20 multiply by using the distributive principle.

13. $(a + b)(c + d) =$

(a) $c(a + b) + d = ac + cb + d$
(b) $c(a + b) + d(a + b) = ac + b + ad + b = ac + 2b + ad$
(c) $c(a + b) + d(a + b) = ac + bc + ad + bd$

14. $(x + 7)(x - 5) =$

(a) $x^2 + 7x - 5$
(b) $x^2 + 2x - 35$
(c) $x^2 - 5x + 14$

15. $(a + 2b)(3a - 2b) =$

(a) $3a^2 + 6ab - 2b$
(b) $3a^2 + 4ab - 4b^2$
(c) $3a^2 - 4b - 2ab$

16. $(xy - 3)(xy + 2) =$

(a) $x^2y^2 + 2xy - 6$

(b) $x^2y^2 - 3xy + 2$

(c) $x^2y^2 - xy - 6$

17. $(x^2 + 4)(x^2 - 4) =$

(a) $x^4 - 16$

(b) $x^4 + 4x^2 - 4$

(c) $x^4 - 4x + 8$

18. $(y - 4)(y - 4) =$

(a) $y^2 - 4y - 4$

(b) $y^2 - 8y + 16$

(c) $y^2 - 4y - 8$

19. $(0.5a + 2)(0.1a - 3) =$

(a) $0.05a^2 - 1.5a + 4$

(b) $0.05a^2 + 0.2a - 3$

(c) $0.05a^2 - 1.3a - 6$

20. $(4x + y - 1)(x + 2y) =$

(a) $4x^2 + 9xy - x - 2y + 2y^2$

(b) $4x^2 + xy - x + 2y$

(c) $4x^2 + 3y - 1$

Appendix C

Sample Exercises in Junior High School General Science

AUTO-INSTRUCTIONAL EXERCISE No. 4
GENERAL SCIENCE - SEVENTH GRADE

NOTE: Do not guess on the exercises. Read the statement for meaning and then choose one of the alternatives. Erase on the card the spot under the letter of the choice you have made. If your selection is correct, you will find the letter "R". If you miss the "R" on your first choice, look back at the exercise for an intelligent second choice.

1. Weight is not suitable for use in defining matter because

   (a) weight and mass mean the same thing.
   (b) matter does not have the same weight everywhere in the universe.
   (c) weight and mass have somewhat different meanings.

2. A combination of two or more elements which no longer has the chemical characteristics of the elements which compose it describes

   (a) carbon dioxide.
   (b) molecules of oxygen.
   (c) sugar in water.

3. A physical property of a piece of white pine is

   (a) that it will burn.
   (b) its weight compared to its volume.
   (c) its carbon content.

4. The periodic table (on the chart up in front of the class) is an organization of

   (a) elements.
   (b) chemical compounds.
   (c) protons and neutrons.

5. Chemistry is defined as a study of

   (a) chemical compounds.
   (b) the elementary substances or forms of matter of which all bodies are composed.
   (c) everything in the universe.

6. Weight should be defined as

   (a) a universal property of all matter.
   (b) a force found only on the earth.
   (c) a force of attraction between masses.

7. A chemical property of a substance would be a quality which would

   (a) have something to do with its physical appearance.
   (b) describe conductivity of heat.
   (c) affect its ability to burn or react with another substance.

8. In your text and in preceding exercises the term "system" has been used. (For example: Solar System) It is best defined as

   (a) a set or group of things which together form a whole.
   (b) a group of related things.
   (c) an orderly way of doing something.

9. On our imaginary trip to Mars we thought to take along with us a double platform balance, and with it a set of standard weights (1 gram, 10 grams, 100 grams, and 1,000 grams). We want to bring back to earth 100 gram samples of the materials on the surface of Mars. To do this we must

   (a) get more information because we don't know enough about the gravity of Mars.
   (b) put enough matter on the balance to equal the 100 gram weight for each sample.
   (c) bring 10 grams of each sample because it will probably weigh more on the earth.

10. When an acid reacts with something it is a

(a) chemical reaction.
(b) physical change.
(c) burning reaction.

11. If we see that a substance has an atomic number of 92 we know

(a) that it could be one of several elements.
(b) that it is an isotope of uranium.
(c) that we must have more information to identify the substance.

12. The burning or oxidation of carbon produces heat; therefore, it must be

(a) an exothermic chemical reaction.
(b) an endothermic chemical reaction.
(c) a physical reaction.

13. The radiant energy spectrum describes

(a) heat energy.
(b) chemical energy.
(c) radio wave energy through cosmic ray energy.

14. The star nearest the earth is

(a) approximately 4.5 light years away.
(b) Alpha Centauri (or Alpha Proxima).
(c) 93,000,000 miles away (9.3×10^7 miles).

15. The following reactions have one thing in common.

($S + 0_2 \rightarrow S0_2$; $C + 0_2 \rightarrow C0_2$; $4P + 50_2 \rightarrow 2P_20_5$). It is

(a) they are all elements.
(b) all are oxidation reactions.
(c) there are metals in each reaction.

Appendix D

Sample Exercises in Human Growth and Learning (Educational Psychology)

PERCEPTION AND THE BEGINNINGS OF SELF-AWARENESS

Jerome S. Bruner
and Cecile C. Goodman

Value and Need as Organizing Factors in Perception[1]

From *Journal of Abnormal and Social Psychology*, 1947, 42:33-44. Reprinted and abridged by permission. The reader will find a review of the related literature by referring to the original source.

Throughout the history of modern psychology, until very recent times, perception has been treated as though the perceiver were a passive recording instrument of rather complex design. One might, in most experiments, describe him in much the same graphical terms as one uses to describe the latest piece of recording apparatus obtainable from Stoelting or the American Optical Company. Such psychology, practiced as it were *in vitro*, has fallen short of clarifying the nature of *perception* in everyday life much as did the old nerve-muscle psychophysiology fall short of explaining *behavior* in everyday life. Both have been monumentally useful—in their place. The names of Weber, Fechner, Wundt, Titchener, Hecht, and Crozier are safely ensconced in any respectable psychological hall of fame. But their work, like the work of the nerve-muscle men, is only a beginning.

For, as Professor Thurstone [28] has put it, "In these days when we insist so frequently on the interdependence of all aspects of personality, it would be difficult to maintain that any of these functions, such as perception, is isolated from the rest of the dynamical system that constitutes the person." The problem is, indeed, to understand how the process of perception is affected by other concurrent mental functions and how these functions in

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[1] The writers are greatly indebted to Pauline B. Hahn and Dr. Leo J. Postman for invaluable assistance and advice.

their turn are affected by the operation of perceptual processes. Given a dark room and a highly motivated subject, one has no difficulty in demonstrating Korte's Laws of phenomenal movement. Lead the subject from the dark room to the market place and then find out what it is he sees moving and under what conditions, and Korte's Laws, though still valid, describe the situation about as well as the Laws of Color Mixture describe one's feelings before an El Greco canvas.

It is the contention of this paper that such perceptual phenomena are as scientifically measurable in terms of appropriate metrics as such more hallowed phenomena as flicker fusion, constancy or tonal attributes. But let us pause first to construct a sketchy terminology. Let us, in what ensues, distinguish heuristically between two types of perceptual determinants. These we shall call *autochthonous* and *behavioral*. Under the former we group those properties of the nervous system, highly predictable, which account for phenomena like simple pair formation, closure, and contrast, or at another level, tonal masking, difference and summation tones, flicker fusion, paradoxical cold, and binaural beats. Given ideal "dark room" conditions and no compelling distractions, the "average" organism responds to set physical stimuli in these relatively fixed ways. Autochthonous determinants, in brief, reflect directly the *characteristic* electrochemical properties of sensory end organs and nervous tissue.

Under the category of *behavioral* determinants we group those active, adaptive functions of the organism which lead to the governance and control of all higher-level functions, including perception: the laws of learning and motivation, such personality dynamics as repression, the operation of quasi-temperamental characteristics like introversion and extraversion, social needs and attitudes, and so on. Underlying these behavioral determinants, doubtless, are a host of physiological mechanisms. But we can hardly wait until we understand these before tackling experimentally the role of behavioral determinants in perception. The physiology of Weber's Law is still more or less obscure, yet the enunciation of it has been recognizably useful—even to the physiologist for whom it has been a challenge to discovery.

The organism exists in a world of more or less ambiguously organized sensory stimulation. What the organism sees, what is *actually there* perceptually represents some sort of compromise between what is presented by autochthonous processes and what is selected by behavioral ones. Such selection, we know, is determined not only by learning, as already indicated, but also by motivational factors such as have been indicated for hunger by Sanford [24, 25] and Levine, Chein, and Murphy. [17] The selective process in perception we shall refer to as a *perceptual hypothesis*, using the term with Krechevsky [14], to denote a systematic response tendency. Such an hypothesis may be set into operation by a need, by the requirements of learning a task, or by any internally or externally imposed demands on the organism. If a given perceptual hypothesis is rewarded by leading to food, water, love, fame, or what not, it will become *fixated;* and the experimental literature, notably the work of Ellson [7] and Leeper [16], indicates that the fixation of "sensory conditioning" is very resistant to extinction. As fixation takes place, the perceptual hypothesis grows stronger not only in the sense of growing more frequent in the presence of certain types of stimulation, but also more perceptually *accentuated*. Perceptual objects which are habitually selected become more vivid, have greater clarity or greater brightness or greater apparent size.

Two other systematic matters must concern us before we turn to the experiments. One has to do with perceptual *compromise*, the other with perceptual *equivocality*. Frequently, alternative hypotheses operate: a quick glimpse of a man in gray on a European battlefield may leave us in doubt as to whether he is a civilian or a Wehrmacht infantryman. Almost inevitably one or the other hypothesis prevails, and the field is perceived as either one or the other. But in spite of the dominance of a single hypothesis in perception, *compromise* also occurs. Using Ansbacher's experiments [2] as an example, a group of small paper squares is seen both in terms of number and in terms of value as stamps. What results, if you will, is a perception of "number-value." We know precious little about such perceptual compromises, although we shall be discussing experiments demonstrating their operation.

As for *equivocality*, or ambiguity in the perceptual field, it has generally been supposed that the greater the equivocality the greater the chance for behavioral factors in perception to operate, all other things being equal. Sherif [26] chose the autokinetic phenomenon to work with for this reason. Proshansky and Murphy [23] worked close to threshold illumination with similar intent. Within broad limits, which we shall discuss, the generalization is valid, in so far as equivocality reduces the organizing capacity of autochthonous perceptual determinants. How important this generalization is we, who think so exclusively in terms of the well-controlled dark-room experiment, often forget. For in everyday life, perception is, by and large, a series of quick looks, glances, inattentive listenings, furtive touches. Save for what is at the very focus of interested attention, the world of sense is more equivocal than our textbook writers seem to think.

EMPIRICAL HYPOTHESES

We may turn now to the experiments with which this paper is primarily concerned. Three general hypotheses, growing out of the systematic principles just presented, are under consideration.

> 1. *The greater the social value of an object, the more will it be susceptible to organization by behavioral determinants.* It will be *selected* perceptually from among alternative perceptual objects, will become *fixated* as a perceptual response tendency, and will become perceptually *accentuated.*
>
> 2. *The greater the individual need for a socially valued object, the more marked will be the operation of behavioral determinants.*
>
> 3. *Perceptual equivocality will facilitate the operation of behavioral determinants only in so far as equivocality reduces the operation of autochthonous determinants without reducing the effectiveness of behavioral determinants.*

In the experiments reported here, only one aspect of behavioral determination will be treated, what we have called *accentuation* —the tendency for sought-after perceptual objects to become more vivid. Perceptual selectivity and fixation have already been demonstrated in other experiments, though they remain poorly systematized. For purposes of economy of exposition we omit consideration of them here, though they constitute important variables in the broader research project of which the present experiments are a part.

THE SUBJECTS AND THE APPARATUS

The subjects were 30 ten-year-old children of normal intelligence, divisible according to certain characteristics to be discussed shortly into three groups, two experimental and one control. The apparatus consisted of a rectangular wooden box (9" x 9" x 18") at one end of which was a 5" square ground-glass screen and a knob at its lower right-hand corner. At the center of the ground-glass screen was an almost circular patch of light (16.2 app. ft. cdls.) cast upon the back of the screen by a 60-watt incandescent light shining through an iris diaphragm which could be varied in diameter from ⅛" to 2" by turning the knob on the front end of the box. All that was visible to the subject was the box with its ground-glass screen and the circle of light whose diameter he could change by turning the knob. The circle was not truly round, containing the familiar nine elliptoid sides found in the Bausch & Lomb iris diaphragm. It was so close to round, however, that subjects had no difficulty making the subjective equations required of them.

Subjects individually sat in a chair in front of the screen on the box with the light circle slightly below eye level. The box rested on a table behind which sat the experimenter. The child was told that this was a game, and that he was to make the circle of light on the box the same size as various objects he was shown or told about. Before beginning judgments, each child, with no urging, was encouraged to see how large and small the circle of light could be made.

The two experimental groups received the same treatment. Two series were run for these groups, comprising 20 of the children in all. First the child was asked to estimate the sizes of coins from a penny through a half dollar from memory. He did the first in ascending order of value, then in descending order, always making two judgments for each coin named, one from the open, the other from the closed position of the iris diaphragm. Four judgments were made for each coin by each child. No inkling was given the child as to how "close" he had come.

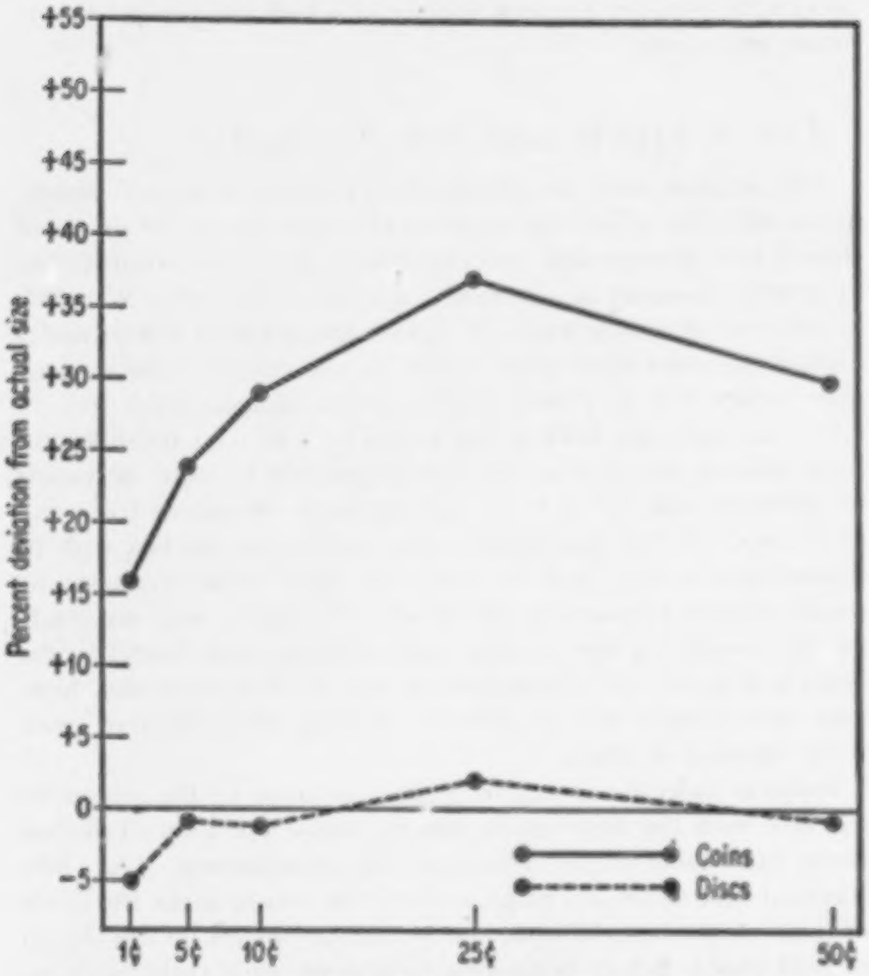

Fig. 1. Size estimations of coins and discs of same size made by ten-year-olds. (Method of average error)

Following the memory series, and using the same order of presentation, a similar series was then run with coins present. Coins, individually, were held close to the center of the palm of the left hand, at a level with the light circle and six inches to its left. The subjects took as much time as suited them.

A control group of ten subjects followed a procedure identical with the one just described. Instead of coins, medium gray cardboard discs of identical size were employed. No mention of money was made to this group.

RESULTS

Let us compare the difference between judgments of size of coins and identically sized cardboard discs. Two things can be noted in Figure 1, which presents judgments of experimentals and controls with coins present. First off, coins, socially valued objects, are judged larger in size than gray discs. Secondly, the greater the value of the coin, the greater is the deviation of *apparent* size from *actual* size. The exception to this generalization is the half dollar, overestimation of which falls off below that of a quarter. By way of the sheerest guess one might explain this reversal of the curve in terms of the lesser reality-value of a half dollar as compared with a quarter for the ten-year-old. A half dollar at that age is, so to speak, almost too valuable to be real! More likely there is some simple autochthonous reason for the reversal. Yet, no such reversal is found in curves plotted for adults.

The difference between experimentals and controls is, of course, highly significant. The variance in overestimation in the experimental groups introduced by using coins of different value is similarly significant. Our results, as handled by the Postman-Bruner [22] adaptation of the analysis of variance to psychophysical data, show that variances due to coin value and due to using discs *versus* coins yield F-scores convertible to P-values of less than .01.[2]

So much for the first hypothesis, that socially valued objects are susceptible to behavioral determinants in proportion to their value. Consider now the second hypothesis, that the greater the subjective need for a socially valued object, the greater will be the role of behavioral determinants of perception. In the second experimental variation, the experimental group was divided into two component groups. One we call the *rich* group, the other the *poor* group, each comprising ten subjects. Well-to-do subjects were drawn from a progressive school in the Boston area, catering to the sons and daughters of prosperous business and professional people. The poor subjects came from a settlement house in one of Boston's slum areas. The reasonable assumption is made that poor children have a greater subjective need for money than rich ones. When the figures presented in Figure 1 are broken down into scores for rich and poor groups, a striking difference will be noted (Figure 2). The poor group overestimates the size of coins considerably more than does the rich. Again there are some irregularities in the curves. The drop-off for the half dollar we have already sought to explain. As for the dip in the rich group's curve at a dime, the explanation is problematical. All curves which we have plotted for adults—and by now we have collected more than two thousand judgments [6]—show this dip. Perhaps it is due to the discrepancy between the relative size and value of the dime, perhaps to some inherent characteristic of the coin itself.[3]

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[2] P-values at the .01 level were also found for constant errors introduced by ascending and descending value orders and for judgments made from the open and closed positions of the diaphragm. Since these parameters were controlled and valanced in the judgment data for the groups discussed, nothing further need be said of them here. They will be discussed in another place. [6] Analysis of variance was carried out both with percentage scores representing deviation of individual judgments from actual size and with raw scores. Necessary corrections suggested by Snedecor [27] were used in the former method. The values presented here are applicable to both raw and percentage scores.

The difference between rich and poor is highly significant, analysis of variance showing that the source of variance is significant beyond the P level of .01. Our second hypothesis cannot, then, be rejected. It is notable too that the interaction between the parameters of economic status and value of coins yields an F-score convertible to a P-value between .05 and .01 which leads to a secondary hypothesis: given perceptual objects of the same class but varying in value, the effect of need for that class of objects will be to accentuate the most valuable objects most, the least valuable least, etc.

What of ambiguity or perceptual equivocality? We have arbitrarily assumed that a situation in which one is judging size from

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[3] If the reader is a smoker, let him ask himself whether a dime will cover the hump on the camel which appears as a trademark on Camel cigarettes. Hold the two six inches apart. In spite of the apparently small size of the coin it will cover the camel's hump with margin to spare.

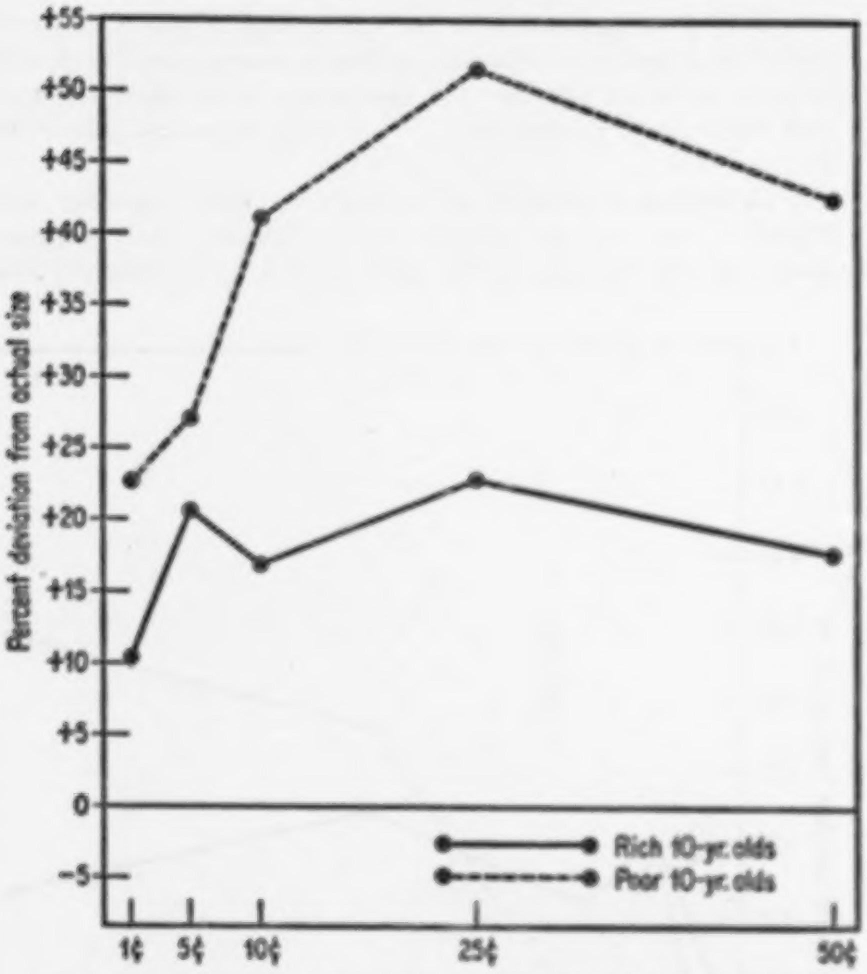

Fig. 2. Size estimations of coins made by well-to-do and poor ten-years-olds. (Method of average error)

memory is more "equivocal" than one in which the object being judged is in clear view six inches away from the test patch. The assumption is open to serious question, but let us examine what follows from it experimentally. Compare first the judgments of the rich group under conditions like those described: with coin present as compared with coin as a mere memory image. The curves are in Figure 3. It would seem that, for all values below a quarter, equivocality has the effect of making judgments conform more to actual size, aiding, in other words, the operation of autochthonous determinants. For values over a quarter, equivocality favors behavioral factors, making apparent size diverge still more from actual size. For the rich group, with coin *present*, a half dollar is overjudged by 17.4 per cent; with coin *absent*, by 34.7 per cent.

This finding is difficult to interpret by itself. Consider now Figure 4, showing the discrepancy in "absent" and "present" judgments for the poor group. Here there is no crossing. Equivo-

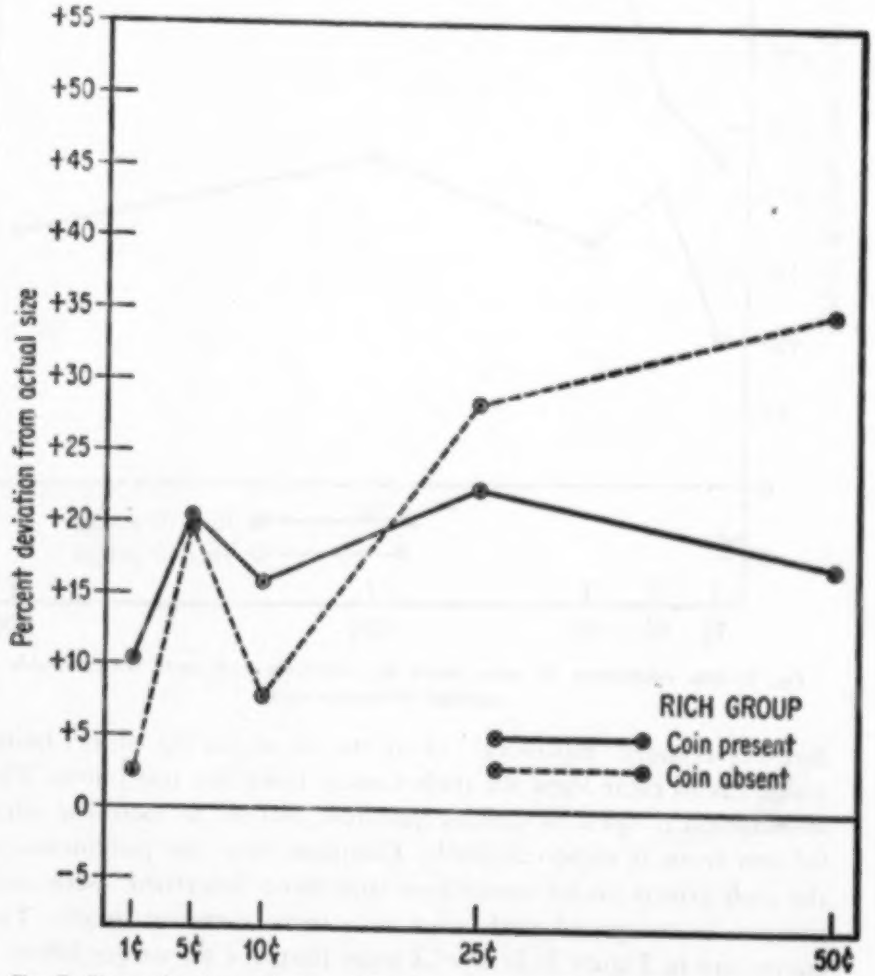

Fig. 3. Size estimations of coins with coins present and from memory by well-to-do ten-year-olds.

(Method of average error)

cality seems, in this group, to have the exclusive effect of bringing judgments down toward actual size. Equivocality even brings out the "dime dip" in the poor group. How account for the difference? Why does equivocality liberate behavioral determinants among the rich children for higher values, and depress these factors for poor children? We can offer nothing but a guess, one which needs confirmation by further research. Some years ago, Oeser [19] reported that in his study of children in Dundee he

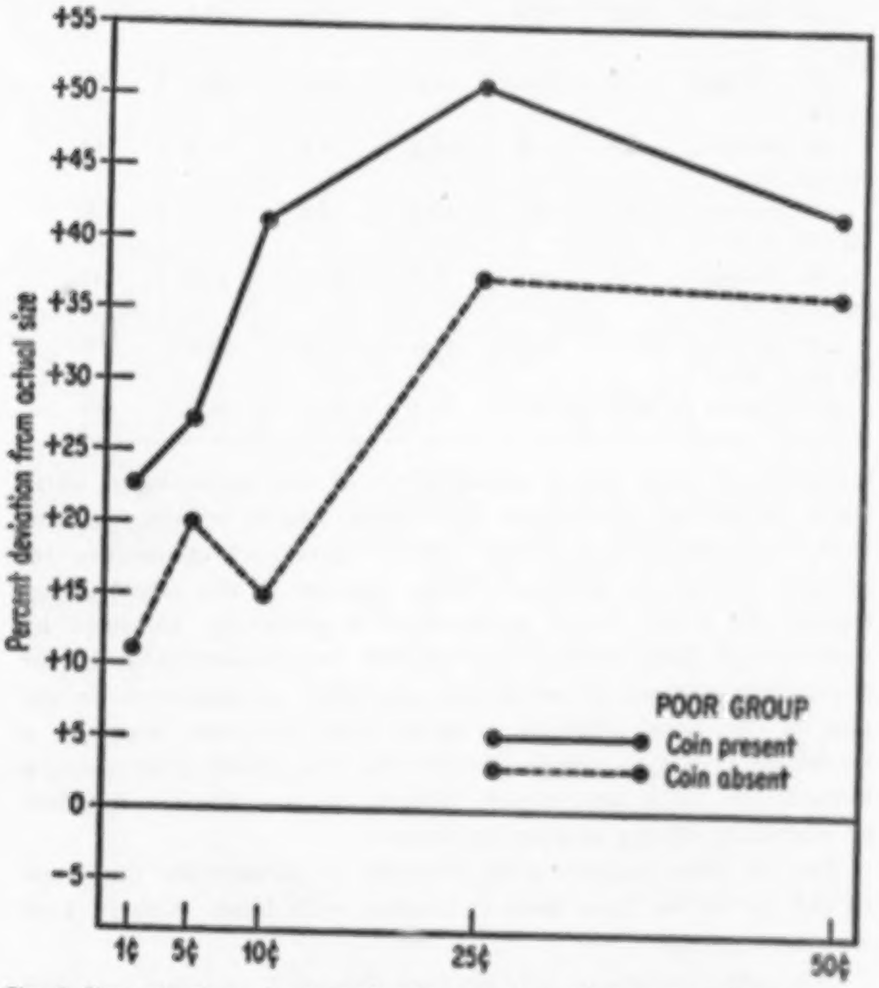

Fig. 4. Size estimations of coins with coins present and from memory by poor ten-year-olds.

(Method of average error)

TABLE 1

PERCENTAGE DEVIATION FROM ACTUAL SIZE OF JUDGMENTS OF COINS AND DISCS UNDER VARIOUS CONDITIONS

Group and Condition	*Penny*	*Nickel*	*Dime*	*Quarter*	*Half-dollar*	*Number Judgments per Coin*
20 *O*'s coin present	16.5	23.9	29.1	37.0	29.6	80
20 *O*'s coin absent	7.2	19.6	11.6	32.8	35.8	80
10 *O*'s disc present	—5.4	—.9	—1.5	1.8	—.8	40
10 rich *O*'s coin present	10.3	20.4	16.3	22.4	17.4	40
10 rich *O*'s coin absent	2.6	19.8	7.8	28.3	34.7	40
10 poor *O*'s coin present	22.7	27.3	41.8	51.6	42.0	40
10 poor *O*'s coin absent	11.8	19.4	15.4	37.3	36.9	40

found the fantasy life of the children of the unemployed strikingly choked off. Asked what they would like to be when grown, normal children of employed parents gave such glamorous replies as cowboy or film star, while children of the unemployed named the rather lowly occupations traditionally followed by members of their class. In the figures just presented, it is our contention that we are witnessing the same phenomenon. In the case of the poor children, judging coin size from memory, a weakened fantasy is substituted for the compelling presence of a valued coin, while among rich children equivocality has the effect of liberating strong and active fantasy.[4]

Are any other explanations available to account for the shape of the curves we have been concerned with here? Weber's Law would predict in all cases a straight line plot parallel to the axis representing actual size. DL should be a constant fraction of the stimulus, whatever its magnitude. If one were to treat the slope of the curves by reference to Hollingworth's central-tendency effect [11], one should find a negative rather than a positive slope. All values smaller than the center of the series should appear larger in size; all larger than the center of the series, smaller. Assuming that the Hollingworth effect is mediated by autochthonous factors, then it represents one more autochthonous factor outweighed by the behavioral determinants discussed in the course of this paper.

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[4] The difference between rich and poor children in their size judgments of "absent" and "present" coins as here discussed is statistically significant. The interaction variance for these two parameters (economic status and presence-absence of coins) is at the .01 level of significance.

In conclusion, only one point need be reiterated. For too long now, perception has been virtually the exclusive domain of the Experimental psychologists with a capital *E*. If we are to reach an understanding of the way in which perception works in everyday life, we social psychologists and students of personality will have to join with the experimental psychologists and reexplore much of this ancient field of perception whose laws for too long have been taken for granted.

Value and Need as Organizing Factors in Perception

In this class you were earlier asked to read a brief paper on values and needs as organizing factors in perception. Please answer the following questions on the separate answer sheet provided.

1. Who is Jerome S. Bruner?

   (a) A German psychologist
   (b) Director of the Institute of Child Development
   (c) A Harvard professor

2. What is an El Greco canvas?

   (a) a type of cloth made in Greece
   (b) a painting by a Greek living in Spain
   (c) a painting in the Greek manner

3. Which of the below is not the results of a perceptual hypothesis becoming fixated?

   (a) variable
   (b) brightness
   (c) clearness

4. What is perceptual equivocality?

   (a) ambiguity
   (b) balancing
   (c) unintelligibility

5. What general hypothesis is not under consideration in this paper?

   (a) The greater the individual need for a socially valued object, the more marked will be the operation of behavioral determinants.
   (b) Perceptual equivocality will facilitate the operation of behavioral determinants only insofar as equivocality reduces the operation of autochthonous determinants without reducing the effectiveness of behavioral determinants.
   (c) The stronger the autochthonous determinants the stronger the effect of the behavioral determinants.

6. What is a parameter?

   (a) a many sided figure
   (b) a constant defining the curve of the equation for some psychological function
   (c) a special meter measuring several variables simultaneously.

7. How did children of poor parents differ from children from well-to-do families? They tended to overestimate size of coins

   (a) more.
   (b) decreasingly as they went to less familiar more valuable coins.
   (c) increasingly more from penny to quarter.

8. Children of poor parents tend ______________ to overestimate when coins are present than from memory.

   (a) more
   (b) less
   (c) about the same

9. What is DL?

(a) difference
(b) differential limen
(c) discount loading

10. What is a limen?

(a) law
(b) nerve lining
(c) threshold

11. Probably poor children overestimate less when coins are absent because

(a) no good explanation is known.
(b) they know the coins less.
(c) their fantasy life is more meagre.

12, The least added difference of stimulus that can be noticed is a constant proportional part of the original stimulus. This is

(a) Weber's law.
(b) Wundt's law.
(c) the law of least returns.

13. What does heuristic mean?

(a) exuberant
(b) leading to a discovery
(c) hewing to a line of argument

14. What does autochthonous mean?

(a) automatic
(b) generated without thought
(c) originating within an x organism

15. Which is not an autochthonous phenomenon?

(a) contrast
(b) repression
(c) flicker

16. What is a behavioral determinant of perception?

(a) summation
(b) motivation
(c) masking

17. What may set a perceptual hypothesis in operation?

(a) a need
(b) an especially strong stimulus
(c) tonal masking

18. How is a perceptual hypothesis fixated? By

(a) exceptional strength
(b) repetition
(c) reward

19. Perceptual processes then become more

(a) accentuated
(b) dim
(c) erratic

20. What is an example of perceptual compromise? Seeing several small paper squares in terms of

(a) figures simply making a pattern.
(b) either number or value as stamps.
(c) figures of uncertain number.

21. Which aspect of behavioral determination is treated in the experiments reported in this paper?

(a) accentuation
(b) equivocality
(c) compromise

22. The children were in two experimental groups and a control group. How many were in each group?

(a) Ten.
(b) All the children participated in all three experiments.
(c) The exact number is not given.

23. The apparatus consisted of a box with an illuminated glass screen in front and a knob with which the child could

(a) turn the light off or on.
(b) change its brightness.
(c) change the size of the illuminated area.

24. Each child in the experimental groups was first asked to estimate from memory the

(a) total value.
(b) value to him.
(c) size.

25. The control group was asked to make similar judgments about

(a) coins held at different distances so they looked the same size.
(b) gray cardboard discs the same size as the coins.
(c) slugs the same size and color.

26. What was not an important finding from the above comparison?

(a) The coins were judged larger than the pasteboard discs.
(b) The more valuable coins tended to be overestimated.
(c) More intelligent children estimate the size more closely.

27. As compared to children of well-to-do parents, children from a settlement house

(a) overestimate the size of coins less, since they have less money.
(b) overestimate the coins more.
(c) judge more accurately, since money means more to them.

28. What was each child in the experimental groups not asked to do?

(a) estimate after handling the coins
(b) estimate beginning with both penny and half-dollar
(c) estimate starting with the diaphragm both closed and open.

Value and Need as Organizing Factors in Perception

In this class you were earlier asked to read a brief paper on values and needs as organizing factors in perception. Please answer the following questions on the separate answer sheet provided.

1. What is a parameter?

   (a) a special meter measuring several variables simultaneously
   (b) a many sided figure
   (c) a constant defining the curve of the equation for some function

2. What is perceptual equivocality?

   (a) balancing
   (b) unintelligibility
   (c) ambiguity

3. What is an El Greco canvas?

   (a) a painting by a Greek living in Spain
   (b) a painting in the Greek manner
   (c) a type of cloth made in Greece

4. Who is Jerome S. Bruner?

   (a) Director of the Institute of Child Development
   (b) a Harvard professor
   (c) a German psychologist

5. What general hypothesis is not under consideration in this paper?

   (a) The stronger the autochthonous determinants the stronger the effect of the behavioral determinants.
   (b) Perceptual equivocality will facilitate the operation behavioral determinants only insofar as equivocality reduces the operation of autochthonous determinants without reducing the effectiveness of behavioral determinants.
   (c) The greater the individual need for a socially valued object. the more marked will be the operation of behavioral determinants.

6. Which of the below is not the result of a perceptual hypothesis becoming fixated?

   (a) clearness
   (b) variable
   (c) brightness

7. What does heuristic mean?

   (a) leading to a discovery
   (b) hewing to a line of argument
   (c) exuberant.

8. Probably poor children overestimate less when coins are absent because

   (a) their fantasy life is more meagre.
   (b) no good explanation is known.
   (c) they know the coins less.

9. What is a limen?

   (a) threshold
   (b) law
   (c) nerve lining

10. What is DL?

(a) difference
(b) discount loading
(c) differential limen

11. How did children of poor parents differ from children from well-to-do families? They tended to overestimate size of coins

(a) increasingly more from penny to quarter.
(b) decreasingly as they went to less familiar more valuable coins.
(c) more.

12. Children of poor parents tend ____________________ to overestimate when coins are present than from memory.

(a) less
(b) more
(c) about the same

13. The least added difference of stimulus that can be notices is a constant proportional part of the original stimulus. This is

(a) the law of least returns.
(b) Weber's law.
(c) Wundt's law.

14. Which aspect of behavioral determination is treated in the experiments reported in this paper?

(a) equivocality
(b) compromise
(c) accentuation

15. Perceptual processes then become more

(a) dim.
(b) erratic.
(c) accentuated.

16. What may set a perceptual hypothesis in operation?

(a) tonal masking
(b) a need
(c) an especially strong stimulus

17. Which is not an autochthonous phenomenon?

(a) repression
(b) contrast
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18. What is an example of perceptual compromise? Seeing several small paper squares in terms of

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19. How is a perceptual hypothesis fixated? By

(a) repetition
(b) reward
(c) exceptional strength

20. What is a behavioral determinant of perception?

(a) masking
(b) motivation
(c) summation

21. What does autochthonous mean?

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(b) judge more accurately, since money means more to them.
(c) overestimate the size of coins less, since they have less money.

27. Each child in the experimental groups was first asked to estimate from memory the

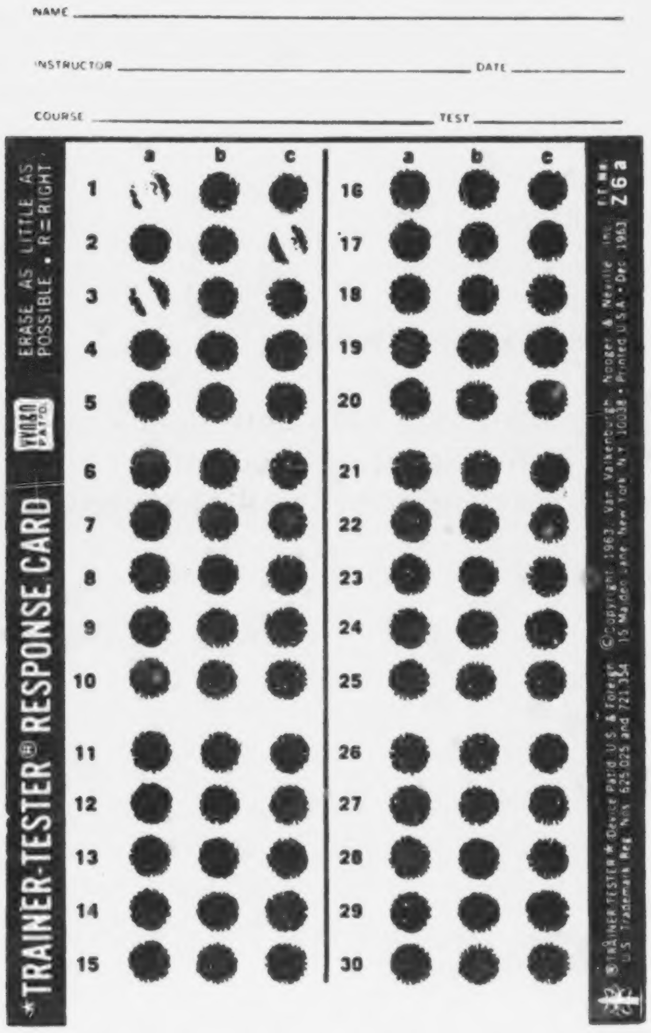
(a) size.
(b) total value.
(c) value to him.

28. What was he not asked to do?

(a) Estimate beginning with both penny and half-dollar.
(b) Estimate after handling the coins.
(c) Estimate starting with the diaphragm both closed and open.

Appendix E

Trainer-Tester Response Card



NAME ____________________

INSTRUCTOR ____________________ DATE __________

COURSE ____________________ TEST __________

*TRAINER-TESTER® RESPONSE CARD

TYOBO PAT'D.

ERASE AS LITTLE AS POSSIBLE • R=RIGHT

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